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COMPANION TRAINER AIRCRAFT: CONCEPT TEST

By

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This report has been reviewed and is approved for publication.

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SUMMARY

Objectives

The objective was to identify potential problem areas or constraints that would affect the viability of using a small business jet, or Companion Trainer Aircraft (CTA), as an adjunct to maintaining aircrew flying skills in the B-52.

Background/Rationale

B-52 continuation training is heavily dependent on flying the actual aircraft, resulting in a very costly training program. This effort addressed the desirability of using small, low operating cost business jet aircraft in conjunction with B-52 flying time to maintain aircrew skills. This effort was part of a larger CTA test that was terminated prior to completion.

Approach

The Air Force modified two T-39 aircraft to represent a typical CTA configuration. B-52 pilots and copilots were dual qualified in these T-39s. Crews then flew missions in the T-39 CTAs in addition to their normal B-52 training. Pilot performance in T-39s was evaluated by Military Airlift Command (MAC) instructor pilots and 4950th Test Wing instructors. The First Combat Evaluation Group (Strategic Air Command) evaluated performance in B-52s. Further data were acquired through interviews with participating crews on other aspects of the test program following the termination of the study.

Specifics

Method. Eight B-52 pilot/co-pilot teams from the Second Bombardment Wing at Barksdale AFB were trained to fly the specially modified T-39 aircraft. They received initial T-39A qualification training at Scott AFB from Military Airlift Command instructors. Conversion training to the modified T-39Bs was provided at Barksdale AFB by 4950th Test Wing instructors. Following this phase, the pilots and copilots flew low altitude training missions with their radar navigators and navigators, as well as a 4950th Test Wing instructor pilot, on board.

Results. During initial qualification training in the T-39, piloting performance in the T-39 improved over sorties but not as rapidly for approach and landing as for other mission phases. Many of the persistent problems seemed to be due to inappropriate generalization of B-52 behaviors to the T-39. A similar pattern of behavior was reported by 4950th Test Wing instructors during conversion training in the T-39B. Intervals of up to 14 days between T-39 sorties seemed to have little effect on pilot performance. Beyond that length of time, T-39 pilot performance was degraded. Crew responses to the program were largely positive. Major complaints concerned the differences in B-52 and CTA navigation equipment, the lack of sensors to support low-level flight, and scheduling problems.

Conclusions/Recommendations

The most persistent problems in second aircraft operation occurred primarily during the approach and landing phase of the T-39 mission and appeared to be due to inappropriate intrusion of B-52 behaviors in the T-39. In a CTA training program, this phase of the mission would need special attention. The interval between CTA sorties also appears to be a critical factor, at least early in the dual qualification process. The present data suggest that this interval should not exceed 2 weeks.

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Faced with increasing budget constraints and a need to conserve the B-52 weapon system, the Strategic Air Command (SAC) has pursued several avenues to make continuation training programs more efficient. Because actual flight training is considered to be critical, one proposed solution involved the use of a low cost business jet aircraft to supplement reduced B-52 flying schedules. This aircraft would be augmented to provide training for the radar navigator, navigator, and electronic warfare officer (EWO), in addition to the pilot and copilot.

Some training missions would be flown in this Companion Trainer Aircraft (CTA) to reduce the need to fly the B-52. The training effectiveness of a CTA program depends on two main assumptions: first, appropriate behaviors

Item 20 (*Continued*)

trained in the CTA will transfer positively to the B-52, and second, inappropriate behaviors will not transfer. A theoretical approach based on transfer-of-learning considerations for a CTA revealed particular difficulties in specifying transfer expectations for pilots and copilots. Previous attempts to use a second aircraft as a surrogate trainer have met with mixed results. Both positive and negative effects on primary aircraft performance were observed. However, these studies did not utilize aircraft modified to resemble the primary aircraft (e.g., instrumentation) nor attempt to fly missions in the secondary aircraft that were similar to those in the primary aircraft. In response to a congressional request for proof of the concept that a CTA could provide effective training, a study was designed involving operational SAC crews. This study employed a modified T-39B aircraft to supplement B-52 training for eight aircrews. The purpose of the study was to answer two major questions. First, what effect does flying the secondary aircraft have on primary aircraft performance? Second, can the crew learn to safely operate the secondary aircraft while continuing to fly the primary aircraft? Although the CTA program was cancelled and the test was terminated, crew responses to the program and problems encountered provide valuable lessons for any future CTA program. The limited data also provide some insights concerning secondary aircraft skill acquisition.

PREFACE

This research was performed to satisfy requirements of Air Force Human Resources Laboratory Technical Planning Objective 3, the thrust of which is air combat tactics and training. The general objective of this thrust is to identify and demonstrate cost-effective training strategies and training equipment capabilities for use in developing and maintaining the combat effectiveness of Air Force aircrew members. More specifically, the research was part of that conducted under the Operational Unit Training Research subthrust, which has as its goal the development and evaluation of skill maintenance and reacquisition training programs. Work Unit 11230252, Companion Trainer Aircraft Research Support, addressed a portion of this subthrust, namely, evaluating the training effectiveness of flying a secondary aircraft to maintain B-52 aircrew mission readiness. Dr. Milton E. Wood was the project monitor, and Dr. Robert T. Nullmeyer was the principal investigator.

The conduct of this research depended heavily on the assistance and participation of a number of personnel from various organizations. Lt Col Robert Lancaster, the CTA Test Director, and Capt Robert Wenning of the 4950 Test Wing (TESTW) conducted the majority of the T-39B training and collected the data on aircrew performance in the T-39B. Capt Clifden Banner, Maj William Edwards, Capt Stephan Lee, and other members of the 1st Combat Evaluation Group (1CEVG) provided crucial support in the development of data collection procedures, design of T-39 training programs, and data collection on the B-52. Maj John Richard, the 2nd Bombardment Wing (2BMW) Test Director, managed on-site operations, and Capts George Gray and Steve Green of the 2BMW conducted training for radar navigators and navigators on the T-39B. Particularly worthy of thanks are the 2BMW crews who participated in the test, for investing their time and energy into a sometimes hectic program. Finally, Ms. Evelyn Beyers deserves notice for her assistance in the production of technical materials and documentation, usually on short notice.

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COMPANION TRAINER AIRCRAFT: CONCEPT TEST

I. INTRODUCTION

Continuation training for the B-52 weapon system currently depends heavily on flight training in the primary aircraft to maintain aircrew skills. The use of this very costly training medium occurs at a time when Strategic Air Command (SAC) is faced with increasing budget constraints and a need to conserve the B-52 weapon system. SAC has pursued several avenues to make the continuation training program more efficient, including the procurement of a ground-based simulator, the B-52 Weapon System Trainer (WST), to augment training. This simulator should remove a significant part of the continuation training burden from the primary aircraft. However, SAC training planners anticipated a limit to the amount of reduction in flying that could be realized from ground-based simulation because many skills, such as management of the air environment and adaptability to flight conditions, may best be learned through practice in the actual flight environment. In addition, a rather sharp decline in average flight experience levels for B-52 crews over the last decade (see, for example, Ropelewski, 1980) was considered by SAC to be a problem that needs to be corrected. As a result, flight training was considered to be a critical part of the continuation training program. To minimize dependence on the B-52 for training, a "triad" of training devices was proposed, consisting of the B-52 WST, reduced use of the primary aircraft, and a low cost business jet aircraft augmented to provide training for the radar navigator, navigator, and electronic warfare officer (EWO) in addition to the pilot and copilot. Some training missions would be flown in this Companion Trainer Aircraft (CTA) to reduce the need to fly the B-52.

As described by the Headquarters Strategic Air Command (1979), the CTA would be a multi-engine commercial business jet aircraft configured to provide transferable training in the areas of (a) general aviation skills, (b) general system/operational skills, and (c) specific system skills. To accomplish this, the pilot station would be modified to resemble the B-52 cockpit, and crew stations would be added for the radar navigator, navigator, and EWO. Cockpit instrumentation would be changed to reflect the B-52, including a B-52-like flight director system, i.e., tactical air navigation/very high frequency omnidirectional and radio range/instrument landing system (TACAN/VOR/ILS) etc., with the primary instruments arranged in the CTA so that the visual scan pattern would be similar to that in the primary aircraft. The offensive avionics station would resemble that of the B-52 in appearance. Radar, heading system, and bombing/navigation system (BNS) operations would be as similar as possible to operations in the B-52. For the EWO, a closed-loop simulation system replicating the B-52 in appearance would display a variety of internally generated threat signals and exercise a wide range of responses. Threat mission scenarios would be programmed prior to flight, and a recording of threats and responses would be made for postflight critiques. There was also the possibility that the threat presentations would be tied into the navigation systems, providing increased realism in terms of geographic factors (e.g., terrain masking effects) and increased crew coordination. No plans were made to include the B-52 gunner in the original CTA concept.

The need for a CTA program rests on two critical assumptions. The first is that ground-based simulation is incapable of providing the training expected from the CTA; current B-52 simulators are inadequate and far from state of the art. As an example, a device presently used for radar navigator and navigator training is actually a reconfigured B-29 simulator (Worthey, 1978). SAC is in the process of acquiring the WST, but until the WST is available, it would not be feasible to evaluate the extent to which ground-based simulation could replace the CTA in long term SAC training plans. The effectiveness of the WST for providing skill maintenance training will, however, be evaluated as a separate effort immediately following the availability of the WST for training.

The second assumption is that training in a dissimilar aircraft would transfer positively in the B-52, reducing the need to train in the primary aircraft itself. Warner, Nullmeyer, Warner, and Killion (1980) attempted to predict both the direction (positive or negative) and the magnitude of transfer of training from the CTA to the B-52, based on the seminal transfer of training work of Osgood (1949). According to Osgood's transfer-of-training surface, the major determinants of predicted direction and magnitude of training transfer are the similarity between situations where task accomplishment occurs and the similarity of the responses. Osgood's surface would predict that transfer of training between the CTA and the B-52 should increase with increased similarity between the two aircraft. This transfer would be positive when response requirements are highly similar, and negative when the response in one context would be inappropriate in the other.

For radar navigators, navigators, and EWOs, high fidelity simulation was expected for the tasks that could be accomplished in the CTA, and therefore, a high degree of positive transfer of training to the B-52 was predicted. For pilots, however, predicting the effects of the CTA program was not as straightforward since the reproduction of a B-52 cockpit in a CTA is obviously impossible, and a high degree of fidelity between the CTA and the B-52 is impractical. Transfer-of-training predictions for pilots were based on stimulus and response similarities. For aircraft-independent behaviors (e.g., instrument procedural skills) where responses trained in one aircraft are appropriate in the other, positive transfer of training should result given sufficient stimulus similarity. To the extent that in similar situations, aircraft specific behaviors learned in one aircraft were inappropriate in the other aircraft (e.g., aircraft handling), negative transfer of training was predicted. This negative transfer would result if a competing response generalized to the wrong situation and interfered with the correct behavior. Because of a number of unknowns, it was difficult to forecast the actual impact of the CTA program on pilot and copilot performance based on this analysis. This is obviously a critical issue since it concerns safety of flight.

Actual data related to the viability of the CTA concept are mixed. The Air Force recently initiated several programs that use surrogate aircraft for pilot training. During the evaluation of a low-cost aircraft augmentation test program (Project Constant Growth), T-37 and T-38 sorties were used to augment reduced primary aircraft flying for mission ready pilots. T-37 training missions were flown by C-141 copilots, and T-38 training missions were flown by F-4E and F-111D pilots. Kantor, Noble, and Reid (1977) studied the perceived value of flying low-cost surrogate aircraft for maintaining pilot skills by surveying the attitudes of participating pilots. The authors concluded that when sufficient primary aircraft flight time is available, additional sorties flown in a surrogate aircraft do not necessarily represent a worthwhile training aid. However, when primary aircraft flying time is substantially reduced, an alternate aircraft can provide useful training for maintaining some pilot skills. A summary of pilot self-assessments of the impact of T-37 or T-38 training on primary aircraft performance is given in Appendix A (Table A-1). Although there are noticeable differences among responses with respect to primary aircraft types, a substantial percentage of pilots in all three groups reported beneficial effects on instrument flying in the primary aircraft, and a large group of fighter pilots reported beneficial effects on formation flying. Detrimental effects on operating procedures were reported by 49% of the pilots across all three groups and more than half of the C-141 copilots reported detrimental effects on primary aircraft handling ability. The perceived impact on overall primary aircraft performance was evenly balanced between beneficial and detrimental effects for all three groups of pilots. This mixed pattern of results suggests that while many pilots found some benefit from dissimilar aircraft training with respect to some general flying skills, problems arose in specific areas for others, especially for C-141 copilots.

Plans for Project Constant Growth originally included the evaluation of B-52 and KC-135 copilots as well, but major reductions in primary aircraft flying time for these crewmembers led to the adoption by SAC of an operational low-cost aircraft program called the Accelerated Copilot Enrichment (ACE) program. T-37 or T-38 training sorties were flown by B-52 and KC-135 copilots in addition to their normal primary aircraft training. Eickhoff (1977) reported the results of a survey regarding the impact of this program from the point of view of the participants, their aircraft commanders, and supervisory/staff personnel. In general, respondents in all three groups indicated improvements in copilot decision-making ability, instrument procedures, general proficiency, and confidence. Problems were indicated concerning limited time availability for copilots, scheduling conflicts, interference with primary duties, and landing in the primary aircraft. Assessments of the impact of the ACE program on primary aircraft performance made both by participating copilots and by their aircraft commanders are provided in Appendix A (Table A-2). Responses from both groups were very positive with landing the primary aircraft emerging as the most critical problem area.

In response to the funding request for the CTA program, the Committee on Appropriations in the U.S. Congress House of Representatives requested a test of the concept that, for aircrew skill maintenance, flying a small jet aircraft could be an acceptable substitute for flying in a B-52. The Air Force experience to date provided mixed results, and the efficacy of the CTA training concept could not be predicted with a high degree of confidence. Therefore, a concept validation test of the CTA was designed to respond to the House Committee request.

One experimental approach originally considered to assess the viability of CTA training was to use a three group design consisting of one group that continued with training as usual, a second group that had primary aircraft flying reduced to a point where performance decrements could be observed, and a third group that was given the same reduced

level of primary aircraft flying, augmented with CTA training. Differences between the first two groups would reveal the effects of reductions in primary aircraft training, and differences between the second and third group would reveal the impact of CTA training. If successful, this design would provide a compelling demonstration of CTA training effectiveness. This approach was not pursued, however, for a number of reasons. The first was that it would involve reducing the mission readiness of the SAC crews in the second group (and potentially the third group as well). This was unacceptable to SAC. The second reason was that the amount of reduction needed to observe reduced performance is not known. GIANT SAMPLE (Charczenki, 1976) was conducted to determine this factor, but was unsuccessful because when flying time was reduced for selected crews, a number of factors other than amount of training changed as well, confounding the results. The third reason was that it was considered difficult, if not impossible, to avoid similar confoundings in this CTA evaluation if the amount of primary aircraft training was reduced with no replacement.

The general approach that was finally adopted was to develop a trial program using specially modified T-39Bs to provide flying training that augmented B-52 flying for eight test crews. For this test, the T-39B cockpit instrumentation was rearranged to duplicate to the greatest extent possible the scan patterns of primary instruments used in the B-52. A radar altimeter was also added to the existing instruments. Figure 1 provides a picture of the modified instrument panel. Radar navigator and navigator stations were also added to the T-39B to provide capabilities for training radar navigation, Inertial Navigation System (INS) positioning, degraded simulated bombing, and crew coordination. The equipment installed included an R-14C radar, an F-16 INS, a true airspeed indicating system, and simulated weapon control panels. The R-14C is a line-of-sight, 90° sector scan, ground mapping radar currently used in the F-105. Figures 2 and 3 present pictures of the radar navigator and navigator stations, respectively.

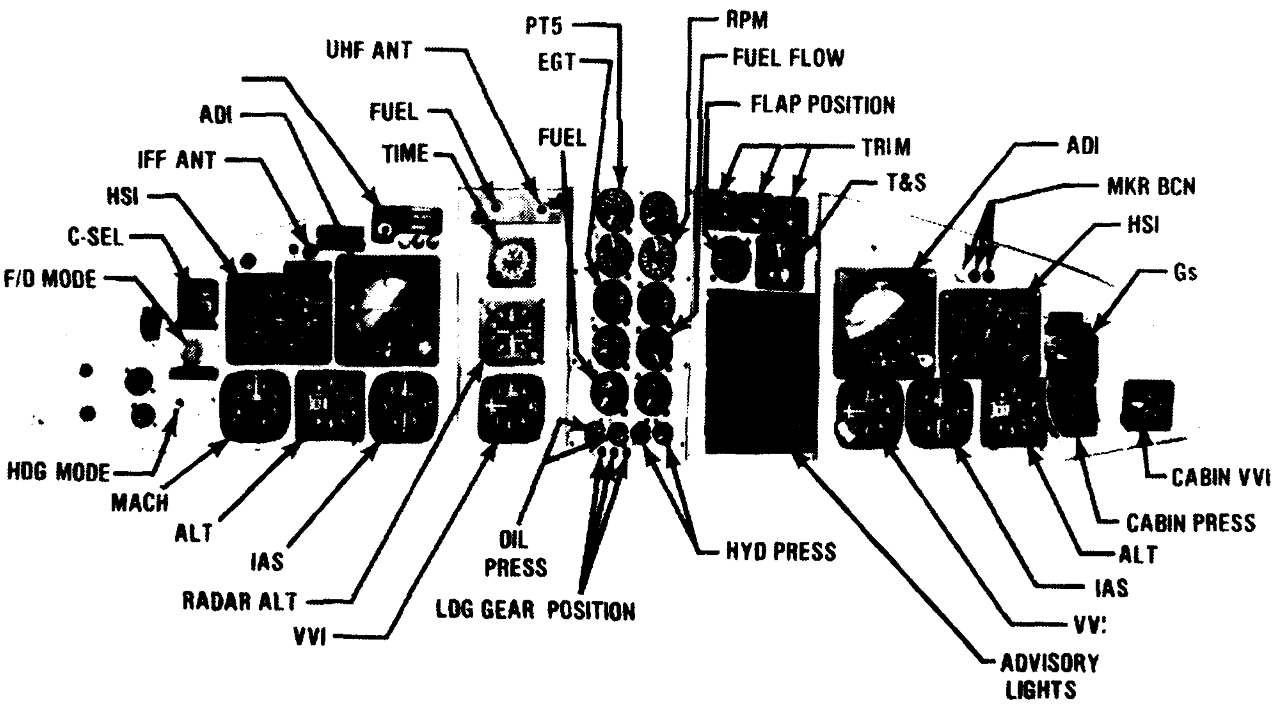
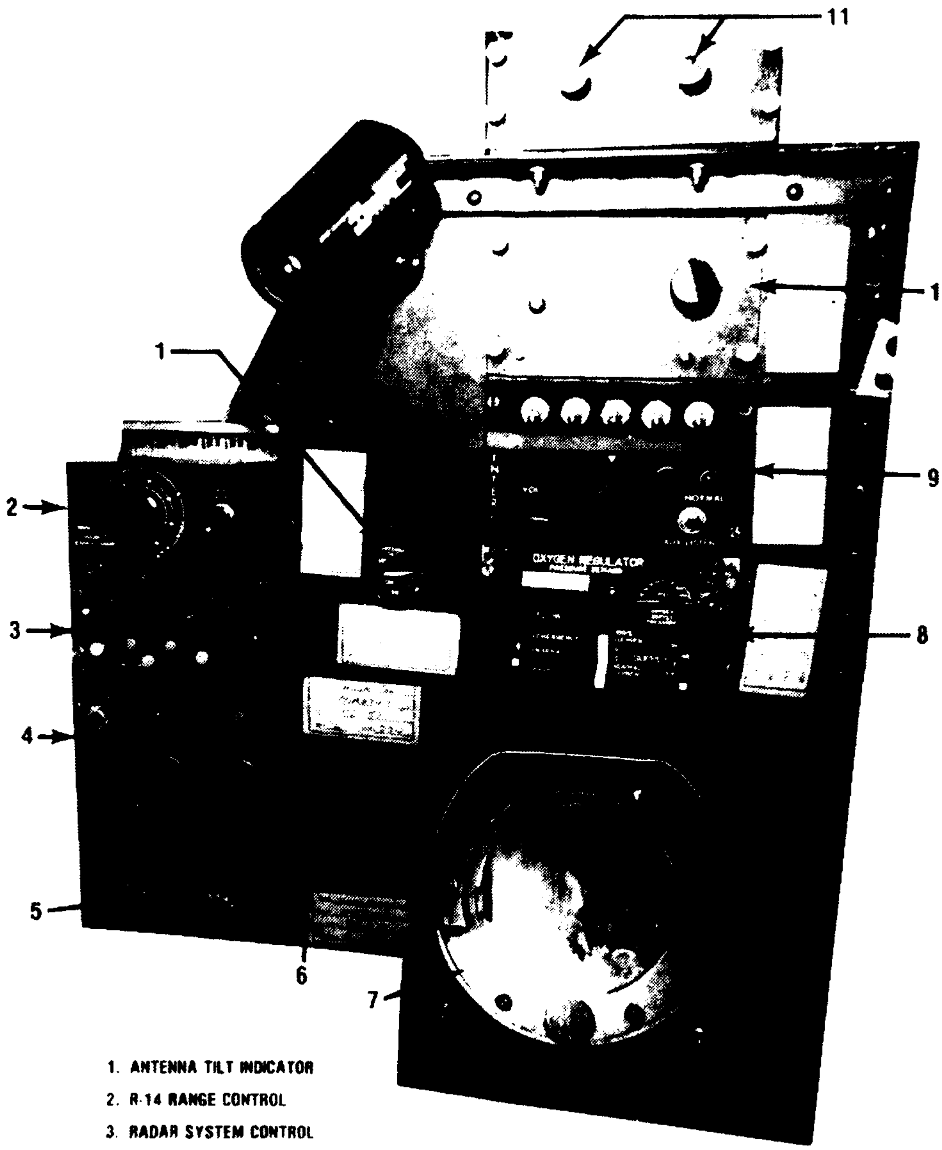
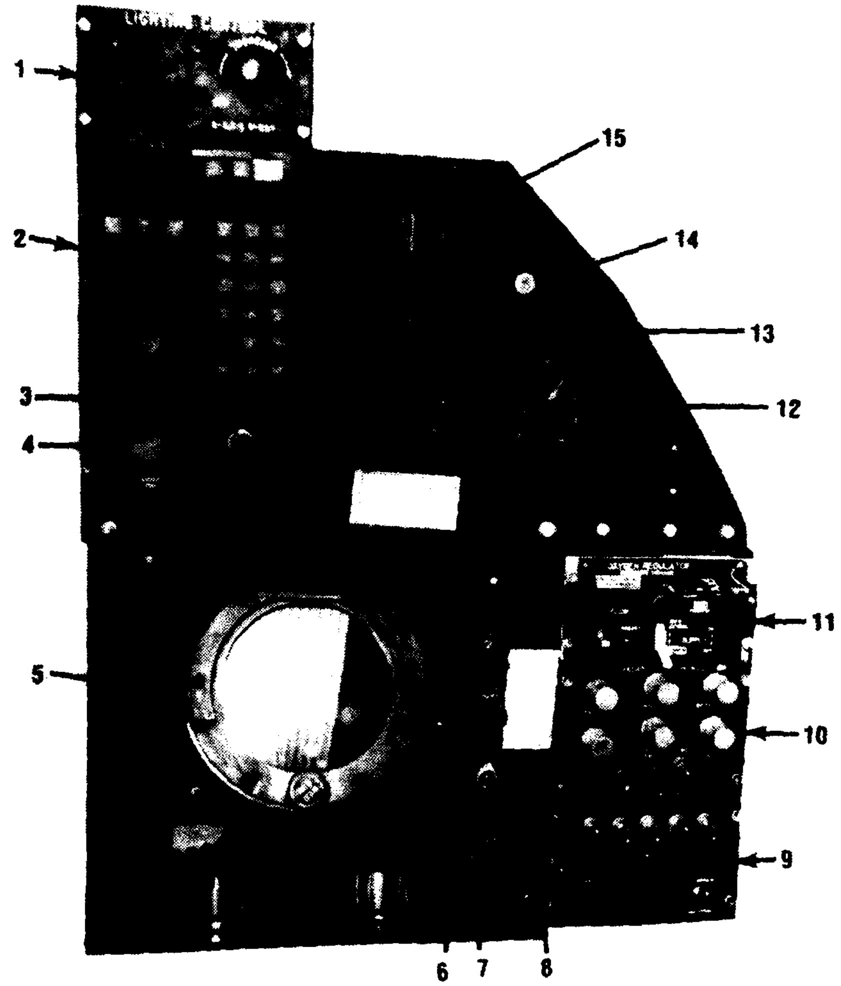


Figure 1. **Pilot/copilot instrument panel.**



1. ANTENNA TILT INDICATOR
2. R-14 RANGE CONTROL
3. RADAR SYSTEM CONTROL
4. R-14 RADAR CONTROL
5. RADAR VIDEO PEDESTAL
6. RADAR MODE INDICATORS
7. R-14 PRIMARY SCOPE
8. OXYGEN REGULATOR
9. INTERPHONE
10. PANEL LIGHTING CONTROL
11. BOMB DOOR CONTROL VALVE LIGHTS

Figure 2. **Radar navigator station.**



1. PANEL LIGHTING CONTROL
2. INS CONTROL & DISPLAY
3. INS FIX DESIGNATOR
4. R-14 REPEATER SCOPE PEDESTAL ADJUST
5. R-14 REPEATER SCOPE
6. RADAR MODE INDICATOR
7. CURSOR DRIFT CONTRL
8. EVENT DESIGNATOR (A/C TEST INSTRUMENTATION)
9. INTERPHONE
10. RADAR CONTROL (REPEATER SCOPE)
11. OXYGEN REGULATOR
12. ALTIMETER
13. COMPASS
14. WATCH HOLDER
15. TRUE AIRSPEED INDICATOR

Figure 3. **Navigator station.**

The performance of these crew members following dual qualification in the T-39B was compared to their performance levels prior to dual qualification. The primary dependent measures were 1st Combat Evaluation Group (1CEVG) proficiency assessments in the B-52, 4950 Test Wing (TESTW) instructor pilot (IP) proficiency assessments in the T-39B, and subjective responses of the participating crews collected at the end of the test. Data collection for the concept validation test began in May 1981. In September 1981, the CTA program was cancelled. At that time, it was decided to terminate the test on 31 October 1981. One result of the program cancellation was to limit the resources available to monitor crew performance. The original design for the test included 1CEVG assessments of performance in the B-52 for a second, *matched group that continued with current levels of training*. However, due to limited resources, this monitoring was not accomplished. The test was also initially designed to include the EWO, using a simulated electronic countermeasures (ECM) suite developed by the Aeronautical Systems Division. However, the test was terminated before this equipment was available, so the test program was limited to pilots, copilots, radar navigators, and navigators. A separate evaluation of this ECM training system is presented in Appendix D to this report.

Two major objectives were addressed by this concept validation test.

1. *Objective 1:* What was the impact of the B-52/modified T-39B training program on aircrew performance in the B-52?

The primary purpose of this objective was originally to determine if a CTA training program would support B-52 skill development and skill maintenance with reduced training in the B-52 itself. However, at the time when the first tests crews were undergoing dual qualification, completion of modifications to the T-39B and final testing of its capabilities were still proceeding. In the interest of avoiding detrimental effects on mission readiness, B-52 flying time was not significantly reduced. By the time all of the test crews had received initial training in the T-39A and both T-39Bs were available, the CTA program had been cancelled. Since the concept test was then scheduled to be terminated on 31 October 1981, this precluded the planned reductions in B-52 activity. Consequently the scope of this objective was reduced to the question of whether T-39B training provided any beneficial/detrimental effects on B-52 performance. The answer to this question could still be valuable information for any planned CTA program, particularly if problem areas were identified. Given the equipment on the T-39B, the utility of such information however, would differ for pilots/copilots and radar navigators/navigators.

Pilots. Due to equipment limitations in the concept test aircraft, valid test results concerning probable CTA training effects might be possible for pilots and copilots only. This was not a serious constraint, since most of the potential training problems associated with the full-up CTA program seemed to involve pilot and copilot training (Warner et al., 1980). The uncertainty of CTA training effects on pilot and copilot performance arose because high fidelity simulation of a B-52 cockpit would not be possible in the candidate aircraft for the CTA program. Differences between the primary aircraft and the CTA would most likely lead to situations where the correct behavior in one aircraft would be inappropriate in the other. If these behaviors generalized from one aircraft to the other, negative transfer of training would result. On the other hand, if training benefits obtained from practicing general flying skills transfer from the CTA to the B-52 while aircraft specific behaviors do not, the CTA concept could represent a viable option for B-52 skill maintenance and crew proficiency training. Because of inherent differences between the proposed CTA and the primary aircraft, assessing the feasibility of the CTA concept for pilots involved assessing both transfer of training of complementary behaviors and the lack of transfer of competing behaviors between aircraft.

Radar Navigators and Navigators. A high degree of fidelity between a full-up CTA and the primary aircraft would be much easier to achieve for radar navigators and navigators than for pilots and copilots. Based on the forecasts made by Warner et al. (1980), CTA training was expected to benefit B-52 performance given high fidelity simulation of B-52 systems operations. As a consequence, testing the concept for these crew stations was not considered to be as critical as was testing the impact of dual qualification on pilot performance.

The radar navigator/navigator station configuration in the concept validation test aircraft was not representative of either the expected CTA configuration or the station in the B-52 itself. In particular, the radar installed in the modified T-39Bs (R-14C radar) differed from B-52 radar in several critical ways. R-14C radar is line of sight while B-52 radar is north oriented, and unlike B-52 radar, R-14C radar has a relatively narrow sector scan and no crosshairs. Some differences, such as picture quality, range marks, and antenna stabilization, were partially correctable prior to the dual

qualification phase of this study. In addition, major B-52 systems, such as the BNS and the SRAM computer, were not represented in the modified T-39B despite their major impact on the tasks of navigation and weapon delivery in the primary aircraft. Some training was expected in dead reckoning navigation procedures, air refueling rendezvous, and possibly fixed angle, target direct bombing. Due to the lack of similarity between the radar navigator and navigator stations in the modified T-39Bs and either the planned full-up CTA or the primary aircraft, the validity of the CTA concept validation test for these positions was questionable. Using T-39B training effectiveness estimates to predict CTA training potential could be inappropriate and misleading because of differences between the modified T-39B and expected CTA designs.

2. *Objective 2.* What was the nature of skill acquisition and what level of proficiency was achieved in the concept test aircraft?

Before training could take place in the T-39B, SAC crews had to be dual qualified. This process was most critical for pilots, but some familiarization training was also necessary for other crew positions. The process of dual qualification for the modified T-39B could provide insights into specific training requirements for the dual qualification of experienced B-52 crews. In addition, monitoring of eventual proficiency levels in the concept test aircraft could indicate the types of tasks that could be trained in the CTA.

Because the pilot station for the concept test aircraft and the T-39 itself were fairly representative of a generic CTA, monitoring performance in the T-39B during the concept test could provide valuable information to be used to plan any future pilot/copilot dual qualification training. If a CTA type program is adopted for B-52 units, such information could guide the dual qualification process and identify particular problem areas or tasks that could not be trained in a CTA.

II. METHOD

Crew Selection

Eight crews were selected from among those available in the SAC 2nd Bombardment Wing (BMW), Barksdale AFB, to participate in the study. The goal was to select these crews such that their experience levels were generally representative of the overall B-52 crew force in terms of pilot and copilot career total/B-52 flying hours. Instructor pilots were eliminated from consideration, as were pilots and copilots who would be affected by an upcoming Permanent Change of Station (PCS) or Date of Separation (DOS). Copilots facing an imminent upgrade to aircraft commander were also removed from consideration. Following this initial filtering, 16 crews remained, 8 from each of the two B-52 squadrons. The two squadron commanders, a training flight B-52 pilot, 1CEVG representatives, and AFHRL personnel divided these 16 crews into two groups, trying to keep experience and proficiency as equally balanced as possible between the groups. Four crews from each squadron were selected for the test group. Because T-39 training for pilots and copilots would incur a 1-year commitment on their part and because test crews would be flying more total hours than normal, inclusion in the test group was made voluntary. Each crew was briefed separately about the test and its expected impact on crew duties. Seven of the eight crews accepted, one declined. The declining crew was replaced by another of the 16 crews. Following crew selection, one of the test group pilots and one copilot had to be replaced due to a PCS and an upgrade, respectively. This occurred before T-39 training had begun, and the same crews, with a replacement pilot and copilot, continued in the test group.

To illustrate how experience levels in the test group compared to the SAC crew force, Figure 4 presents distribution of B-52 and career total flying time for SAC pilots and Figure 5 for copilots. The flying times for the eight test crews are represented in the figures by the number of X symbols appearing under the appropriate portions of the distribution. For example, two of the test crew pilots had B-52 flying time of between 1000 and 1200 hours, so two X symbols appear in that column. Test crew pilots were in the center of the distribution of B-52 and career total flying time. Test crew copilots on the other hand were in the lower ranges of experience. These are the type of copilots (i.e., low time) who would be expected to have the most trouble in a CTA program.

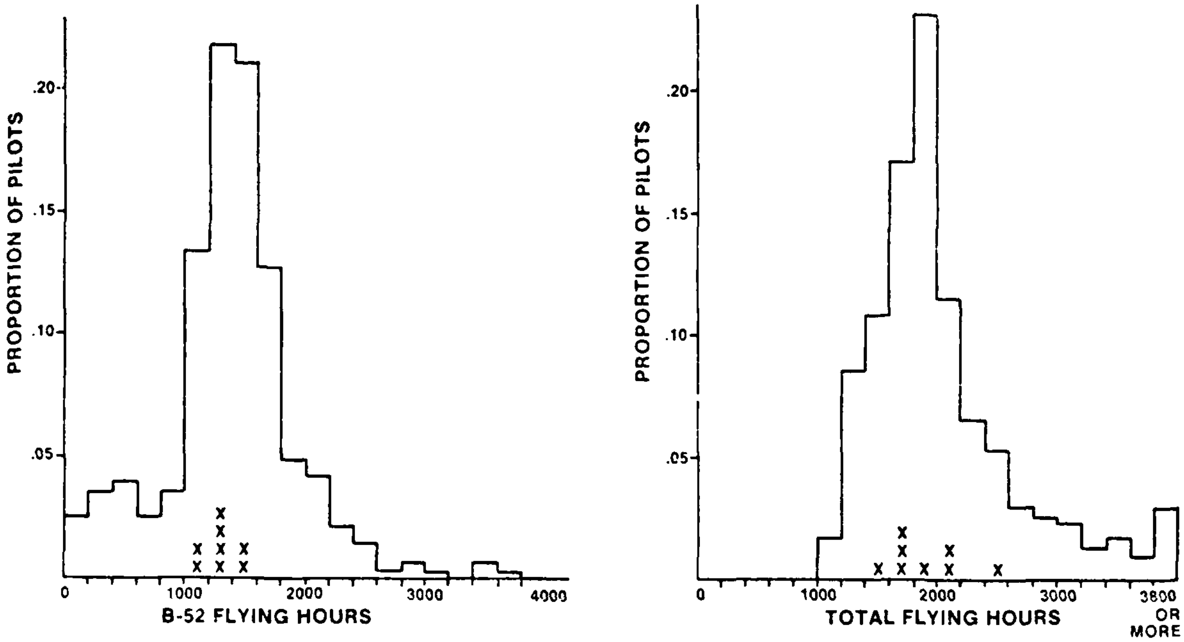


Figure 4. **Distributions of B-52 and total flying time for SAC pilots.**

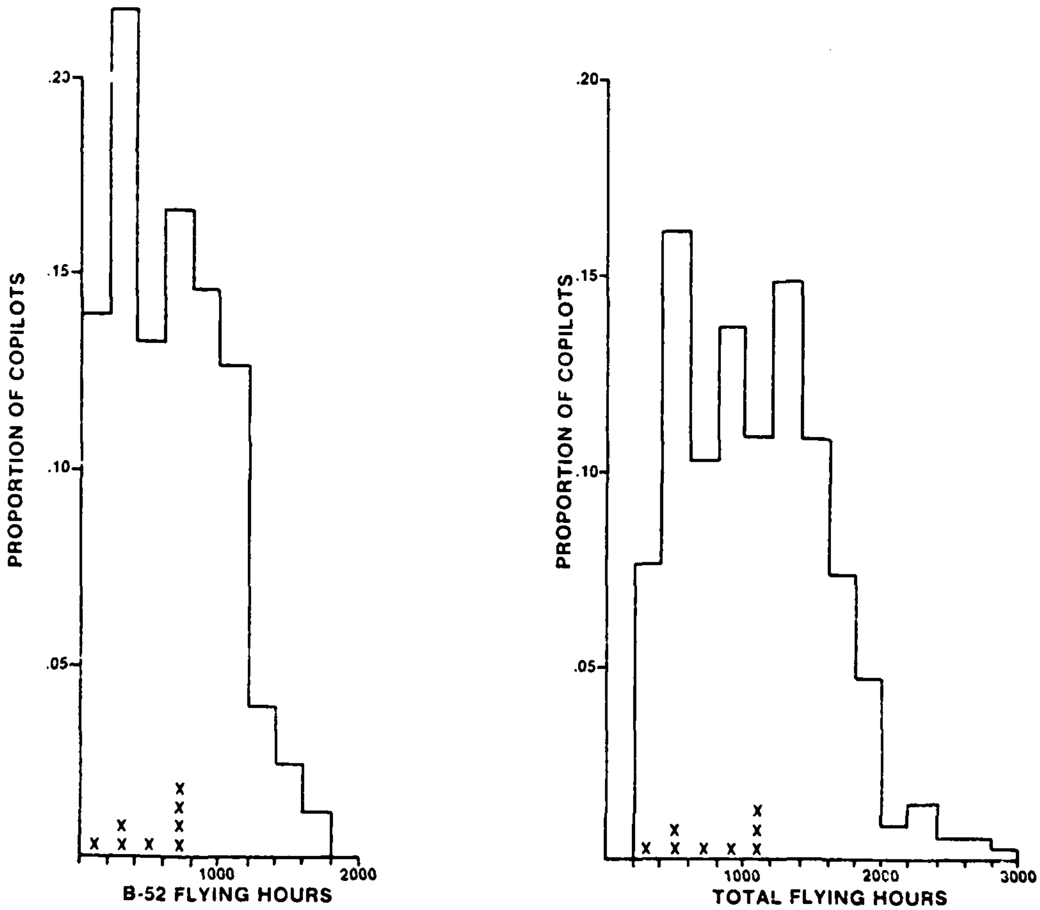


Figure 5. **Distributions of B-52 and total flying time for SAC copilots.**

Dual Qualification

For the purposes of the test, all eight test crews had to fly training sorties in a modified T-39B aircraft. This required training the eight crews in the operation of the T-39B. The process of dual qualification was most elaborate for pilots and copilots.

Pilots and copilots received initial training in the T-39A. Ground school and systems familiarization took place in classes at Barksdale AFB. Pilot/copilot teams were then sent to Flight Safety International for simulator training and to Scott AFB for initial checkout in the T-39A by Military Airlift Command (MAC) IPs. This required a 2-week temporary duty (TDY) assignment. The pilot/copilot teams were sent TDY at 3-week intervals with two crews leaving 29 May, two more on 19 June, and then one crew every 3 weeks until all eight had been trained. Upon return to Barksdale AFB, the pilot teams received conversion training and an initial checkout flight in the modified T-39B.

Following the initial checkout in the T-39B, the pilot/copilot teams began flying low altitude routes with their radar navigators/navigators on board. The first couple of flights were for familiarization and systems training for the offensive team. This training was necessary due to the differences in equipment between the B-52 and the T-39B, particularly for the radar navigator. The familiarization training was provided by 2BMW instructor personnel who had been checked out on the R-14C radar and the INS. Once an offensive team had been checked out by an instructor, further flights were then employed for integral crew training in a low altitude regime.

Data Collection

Procedures for data collection were designed with two purposes in mind: (a) to investigate the impact of T-39 activity on B-52 performance and (b) to trace the acquisition of skill in the T-39. To accomplish the former goal, two types of data were gathered. The first type was evaluations conducted by 1CEVG personnel during routine training missions in the B-52. The second type of data was comments by the crews during interviews conducted at the end of the test. Skill acquisition in the T-39 was monitored using similar procedures. Grades and comments from MAC instructors at Scott AFB were recorded to look at initial training in the T-39A. 4950 TESTW IP evaluations were performed in the T-39B at Barksdale AFB during a variety of training missions. Comments during the final interviews were also utilized.

The 1CEVG and 4950 evaluations employed a data format developed specifically for this test. Initially, B-52 performance measures were selected by 1CEVG and AFHRL based on modified criteria from SAC Regulation (SACR) 60-4. Wherever possible, behavior was to be judged using an objective scale (e.g., feet, degrees, or seconds). Of particular interest were deviations from a planned value (e.g., takeoff airspeed). These will be referred to as tolerance deviations. Other areas were judged using a four-point scale with the following categories: excellent, satisfactory, marginal, and unsatisfactory. These categories were selected due to their familiarity to the evaluators, as they are defined in SACR 60-4. For pilots, the areas graded closely followed SACR 60-4 events. For radar navigators and navigators, SACR 60-4 provided a framework for data collection, but several areas were broken out into finer detail. For all crew positions, crew coordination and communication were included for numerous portions of the mission. The forms developed are displayed in Appendix B.

Similar forms were prepared for use by 4950 IPs on the T-39. These were identical to the B-52 forms wherever possible, but were changed in appropriate areas to reflect differences in equipment and/or operation. These forms are displayed in Appendix C. To perform the ratings, 1CEVG and 4950 personnel would either circle the appropriate symbol (e.g., excellent (E), satisfactory (S), marginal (M), or unsatisfactory (U)) or mark the appropriate location on a scale.

Data were collected by 1CEVG personnel on routine training flights in the B-52 flown by the test crews. For the purposes of the test, 1CEVG instructors acted solely as observers, abrogating their normal responsibility to report unsatisfactory performance. If safety of flight problems arose, the 1CEVG instructor was allowed to intervene and reported the incident to the 2BMW test director, who then arranged for appropriate corrective training. 1CEVG personnel did not provide feedback to the crews on such data collection sorties, so as to have minimal influence on the crew's behavior. The 4950 IP evaluations took place on sorties following the initial "conversion ride(s)" in the T-39B and the familiarization sorties(s) for the radar navigator/navigator. These initial sorties were viewed as primarily instructional, so further duties

for the IP were avoided. Data from these initial sorties were collected from the comments made by the IP in the flight records.

The interview data was collected during the week immediately following the termination of the test. The interviews were conducted at Barksdale AFB, at times which were convenient for the various crews. Each crew in the test group was interviewed separately. Due to TDY or other duties, one pilot and two radar navigators were not able to participate. The interviews were taped for later transcription. During the interviews, a series of questions were directed to the crew members. The following topics were covered:

1. Overall impressions of the program.
2. Changes which they would have made in the program.
3. What, if any, training occurred.
4. Specific problems in the B-52 or the T-39.
5. Probable success of a CTA program, given better equipment.
6. Additional equipment that would be necessary in a CTA.
7. What could/could not be trained in a CTA.
8. Scheduling, for the test program and for a CTA.

Data concerning performance during initial training in the T-39 at Scott AFB came from the training folders of the pilot/copilot teams. The data employed included ratings on MAC Form 21-X and comments from MAC Form 21-1. These ratings and comments were recorded for each of the five training flights in the T-39 at Scott AFB. The ratings used by the Scott IPs were P (proficient) and T (training required).

Data Analysis

Data from the 1CEVG and 4950 IP rating forms were tabulated as to the frequency of each category of rating or tolerance deviation. For ratings on the four-point scale, excellent (E), satisfactory (S), marginal (M), and unsatisfactory (U), data were tabulated in terms of the number of E, S, and M/U ratings. The M and U ratings were combined due to their relative infrequency.

For quantitative scales (e.g., airspeed), data were tabulated in terms of the number of deviations from the recommended value. To clarify this, consider the following scale for deviations in airspeed (in KIAS) during climb/ instrument departure:

−15 −10 −5 0 +5 +10 +15

The zero point refers to the recommended airspeed. The negative values indicate airspeeds below the recommended value, the positive ones above it. The particular values for each scale were based on SACR 60-4 standards and/or 1CEVG recommendations. To tabulate the data, the sign (positive or negative) was ignored. For analysis purposes, the data were categorized in four bins:

(1) Less than one deviation away from the required value (in the above example, between −4 and +4)

(2) From one up to but not including two deviations (from 5 to 9 in either the positive or negative range)

(3) From two up to but not including three deviations (from 10 to 14)

(4) Three or more deviations (15 or more). In reporting these data, the following symbols will be used to refer to the four groups, respectively: (1) < 1; (2) ≥ 1; (3) ≥ 2; and (4) ≥ 3. Once the data were tabulated, it was possible to compute the relative frequencies of the various bins.

In some cases, a transformation of the data was used for analysis purposes so as to avoid the problem of unequal weighting of the overall distributions by differences in the number of observations across individuals and/or conditions. For the rating data, a mean rating was calculated by assigning the values 3, 2, and 1 to the ratings E, S, and M/U, respectively. These values were multiplied by the respective proportion of such ratings and then summed to arrive at a mean rating. The tolerance deviations were handled in a similar fashion, with the values 4, 3, 2, and 1 assigned to the deviations of <1, ≥ 1, ≥ 2, and ≥ 3, respectively.

Comments were solicited along with ratings. Generally, the comments clarified the reasons for less than satisfactory performance. Both comments and interview data will be discussed when they help to clarify the rating data or supplement it.

Limitations

Before discussing the results, several critical factors which limit the conclusions that can be drawn must be mentioned. Most important was the termination of the test on 31 October 1981. Since the first integral crew mission on the T-39B was flown on 16 September, there was very little time to fly training sorties in the T-39B. This limited both the degree of skill acquired in the T-39 (and the attendant data base) as well as the opportunity for changes in performance in the B-52.

The time factor also affected the data collection process, particularly the 1CEVG evaluations. Because of other duties, evaluators were not always available to fly data collection sorties. When it was determined that the CTA program and test were to be terminated, a decision was made to concentrate on evaluations of the test crews. This meant that no comparison data from the monitored group would be available, but at least within-group comparisons could be made. However, such comparisons confound T-39B training with time and so must be viewed with caution. Additionally, radar navigator/navigator performance was not assessed on the T-39B. This was due to the short time available for integral crew missions and the lack of availability of 1CEVG personnel.

These factors affect the utility and generalizability of the data. However, there are interesting trends in the data which are worthy of note. With these cautions in mind, the results can now be discussed.

III. RESULTS

The results of the 1CEVG, 4950 IP, and Scott IP evaluations can be discussed in terms of the two primary issues addressed in this test. First, what impact, if any, did training on the T-39 have on performance in the B-52? Second, what did the skill acquisition process look like and what level of skill was attained in the T-39? These two issues will be discussed separately.

Impact on B-52 Performance

The primary source of data on B-52 performance was the 1CEVG evaluations. A total of 11 evaluation flights were accomplished with various crews in the test group before their pilots/copilots were trained in the T-39. Following T-39A training for the pilot/copilot teams, nine evaluations were performed prior to program termination. Unfortunately, these evaluations were not evenly distributed across crews or conditions. Additionally, when the data were inspected, evidence for an evaluator effect was noted. This limited any comparisons which could be made to those flights which involved the same evaluator as well as the same crew. This severely limited the number of possible comparisons. Concerning the effects of T-39 training, data on performance both before and after such training were available for only two pilots and two copilots. This obviously limits the generalizability of such data. The data on radar navigators and navigators were even more problematic. Essentially, there was only one case where the same evaluator observed a crew both before and after the crew's pilots received T-39 training. Given this limitation, the performance data for radar navigators and navigators will not be discussed any further.

Table 1 presents the mean rating for each B-52 evaluation flight for each pilot and copilot both before and after T-39A training. Also included in the table is a notation concerning which of three evaluators made the ratings. Because there were so few cases where the same evaluator flew with a particular crew both before and after T-39A training, no statistical tests were performed on the data. However, of the seven possible comparisons, six showed an increase in the average rating and only one showed a decrease. The magnitude of the decrease was only .02. Averaged across pilots and copilots, the mean rating before T-39 training was 1.97, after T-39 training it was 2.33. Although these data must be viewed with caution, they do suggest that there was no clear negative impact of T-39 training during the period of this test.

Table 1. **Average Rating for each B-52 Evaluation Flight before and after T-39 Training for each Pilot and Copilot**

		Before T-39 Training			After T-39 Training		
Crew	**Flight No.**	**Pilot**	**Copilot**	**Evaluator**	**Pilot**	**Copilot**	**Evaluator**
1	1	1.90	1.77	A	2.47	2.20	A
	2	1.90	1.80	A	2.79	2.65	C
	3	2.95	2.79	B			
2	1	2.18	2.07	B	2.68	--	B
	2	2.21	2.04	A	2.96	2.92	C
	3				2.19	2.12	A
3	1	2.04	1.96	A	2.83	2.89	B
	2	2.08	2.03	A			
4	1	2.12	1.95	A	2.38	2.27	B
5	1	2.64	2.57	B			
	2	2.63	2.57	B			
	3	2.82	2.80	C			
6	1				2.57	2.31	A
7	1				1.97	1.97	A

One question which could be asked about these data concerns its sensitivity. If the measures are insensitive to critical variables, then any inferences which could be drawn are limited. As a simple test of sensitivity, comparisons were made between the pilot and copilot of each crew. If the measures are valid, they should reflect the difference in experience levels between pilots and copilots. Comparing the average rating for each pilot to that for the corresponding copilot, six pilots show superior ratings, and there is one tie. This is significant by a Wilcoxon test ($\underline{p} < .02$). The average rating for pilots was 2.40 and for copilots was 2.30.

One concern in this test was that the results could be tainted by adaptation to the test environment. That is, the B-52 performance data might be affected simply by the crew becoming used to the presence of an evaluator. One way to look at this possibility would be to compare performance between the evaluation flights prior to the introduction of T-39 training. Although the data available were meager, they did not suggest that any such adaptation was taking place. Considering ratings for each of the four areas (procedures, technique, crew coordination, communication) separately, there were 24 such comparisons possible. Of these, 12 showed improvement across flights, 11 showed a decrement, and one was a tie. Clearly, no significant pattern emerged.

Skill Acquisition in the T-39

The data on skill acquisition in the T-39 comes from two sources, initial training in the T-39A and crew training in the T-39B. These data are of interest for two reasons. First, they can provide a general picture of the process of skill acquisition in a CTA type aircraft. Second, information on particular errors can provide an indication of negative transfer from the B-52 to the T-39. That is, what habits developed in the B-52 seem to carry over into the T-39?

Dual qualification for pilot/copilot teams began with an initial checkout in the T-39A at Scott AFB. Each of these teams received five simulator training sessions and five actual flights in the aircraft. During these training flights, the pilots/copilots were graded by MAC IPs using MAC Form 21-X. The grades used were P (proficient) or T (training required). The pilots/copilots were graded in a variety of areas. Table 2 lists the number of pilots and copilots receiving T grades in each of the applicable areas for each of the first four flights in the T-39A (no T grades were given on the fifth flight). The total number of individuals graded for each area on each flight is presented to the right of the slash. Two patterns in the data are worthy of note. First, the number of T ratings shows a general reduction from the first to the fourth flight. Second, there is a definite trend toward a concentration of errors in the landing portion of the mission in moving from the first to the fourth flight. This second trend reflects the fact that landing is the most difficult portion of the flight. Additionally, landing is the area where differences in handling between the B-52 and the T-39 are most pronounced and was expected to be the most troublesome (Warner et al., 1980).

Table 2. **Number of Pilots and Copilots Receiving a T Rating out of the Number Graded for each of the First Four Training Flights at Scott AFB**

Grading Area	Flight No. 1	2	3	4
Before Takeoff				
a. Crew Briefing	2/12	0/12	0/12	0/12
Takeoff (Rolling/Static)	4/12	2/12	0/14	0/12
Airwork				
a. Runaway Trim	1/11	0/2	0/4	0/2
Instrument Approaches				
a. Instrument Departure and Climb	1/14	0/16	0/15	0/15
b. Descent/Approach Brief	3/14	0/15	0/16	0/15
c. Holding	0/1	1/14	0/8	0/3
d. Procedure Turn	0/9	1/12	0/4	0/6
e. PAR	1/12	1/5	0/9	0/6
f. LOC BC	0/4	1/8	0/3	1/7
g. VOR	2/8	1/11	0/4	0/6
h. Missed Approach	0/1	2/8	1/11	0/8
i. Simulated Single Engine Missed Approach		6/12	1/12	1/10
j. No-Flap Approach	0/4	1/6	0/11	0/11
VFR Approaches				
a. Circling Approach	3/9	2/14	1/15	0/14
b. VFR Pattern	6/12	4/12	1/16	1/16
Landings				
a. Simulated Single Engine	0/1	2/14	0/14	1/15
b. Full-Flap Landing	8/15	6/16	0/16	2/16
c. No Flap	4/9	1/11	0/16	0/14
d. Partial Flap	1/2	0/11	0/15	0/13
e. Emergency Brakes		0/1	1/7	0/9
f. Crosswind Landing Procedure	1/6	2/12	0/10	2/10
g. Wet/Slippery Runway (RW)/Procedure	3/5	4/8	3/12	1/15
Taxi, Braking, Steering	1/14	0/13	0/16	0/14
Checklist Use	10/14	10/16	1/15	1/14
Crew Coordination	2/12	1/13	0/14	0/13

Of particular interest were areas where persistent problems occurred. Table 3 lists the number of pilots/copilots who received a T in the same area on more than one flight. The reasons for these T grades were available from the comments on MAC Form 21-1, which accompanied Form 21-X. Takeoff errors involved pushing the throttles up too high, which can overspeed the engines and the gear. The problems in circling approaches were in being late in configuring the aircraft. For VFR patterns, the errors involved wide and long or steep patterns. On wet/slippery runway procedures, several pilots/copilots flared during the approach, when no flare is desirable. The full-flap landing T grades arose from directional control problems on the runway. Checklist use errors arose from omissions of or mistakes in checklists.

Table 3. **Number of Pilots/Copilots Receiving a T Rating on More than One Flight in the Areas Listed**

Grading Area	No. of Pilots/Copilots
Takeoff (Rolling/Static)	1
VFR Approaches	
a. Circling Approach	2
b. VFR Pattern	3
Landings	
a. Full-Flap	3
b. Wet/Slippery Runway (RW) Procedure	3
Checklist Use	8

These areas where problems were more persistent can be compared to another set of errors identified by 1CEVG. Two 1CEVG IPs were asked independently to judge whether the errors listed in comments on MAC Form 21-1 were related to B-52 habits or not. That is, which errors made in the T-39A appeared to arise from habit patterns developed in the B-52? The IPs were not shown the T grades. The consensus of the two IPs was that the following errors were B-52 related: (a) pushing up throttles too high on takeoff or go-arounds, (b) wide and long VFR patterns, (c) slight crab or directional control problems in landing, (d) high flare and/or early power reductions during the approach, (e) flaring during a wet/slippery runway procedures approach, and (f) large, abrupt control inputs. These problems are clearly related to the areas listed in Table 3. The only items in the table which are not in the 1CEVG list are checklist use and circling approach. These two items could both be attributed to general lack of experience in the T-39. This inexperience could lead to "getting behind the aircraft" or overloading. This problem was most apparent during the approach and landing phase. Where specific checklist errors were identified, eight (36%) of them occurred in the approach or before landing checklists.

These data suggest that habits developed in the B-52 carry over when dual qualifying in the T-39. These habits can be persistent problems, although the intensive training in the simulator and the aircraft did allow the pilots/copilots to overcome them, at least temporarily, in the T-39A (i.e., there were no T grades on the fifth flight in the T-39A). The next step is to examine the problems of concurrent training in the B-52 and T-39B.

The eight crews varied somewhat in terms of the number of flights they accomplished in the T-39B. Even within a crew, there were variations due to availability of the crew members for T-39B activity. Table 4 provides a summary of the number of flights in the T-39B for each crew member from the eight test crews.

Table 4. **Number of Sorties in the T-39 for each Crew Member in the Test Crews**

Crew No.	Pilot	Copilot	Radar Navigator	Navigator
1	10	12	9	9
2	7	5	6	4
3	9	9	8	10
4	6	4	5	5
5	8	6	2	2
6	4	7	3	3
7	7	4	4	4
8	8	8	6	1

For each of the flights, data on pilot/copilot performance were available from comments in the flight record or the 4950 IP evaluations. Table 5 provides a summary of the IP evaluation data on ratings and tolerance deviations in the T-39B for pilots and copilots. There is no apparent difference between pilots and copilots in the ratings; however, the tolerance deviations do reveal a small difference. The more experienced pilots appear to be slightly better than copilots at handling the T-39.

Table 5. **Proportions of T-39B Ratings of each Type (E, S, M/U) and Tolerance Deviations for Pilot and Copilots**

	Ratings			Tolerance Deviations			
Subjects	E	S	M/U	< 1	≥ 1	≥ 2	≥ 3
Pilots	.03	.93	.04	.41	.49	.08	.02
Copilots	.03	.94	.03	.37	.49	.11	.03

Of greater interest is the pattern of tolerance deviations as a function of the number of flights in the T-39B. This provides an insight to the acquisition of skill in the T-39B. Table 6 presents these data for two mission portions, takeoff/climb/level-off and penetration/approach/landing. Pilots and copilots are combined since they both show the same pattern. The data are also divided into three categories of experience in the T-39B: (a) five or fewer flights, (b) six or seven flights, and (c) eight or more flights. Inspecting the changes in tolerance deviations as a function of experience level, an interesting pattern emerges. Basically, there is an improvement in performance on the takeoff/climb/level-off portion of the mission, but no such improvement occurs for penetration/approach/landing.[1] Because the amount of available data was limited, statistical analyses could not be done on these effects. However, the pattern is reminiscent of the T-39A data in that landing reveals a slower learning progression. Presumably, with a greater number of flights, the penetration/approach/landing portion of the mission would also show improvement.

Table 6. **Proportions of T-39B Tolerance Deviations as a Function of Number of Flights in the T-39B and Flight Segment**

	Takeoff/Climb/Level-Off				Penetration/Approach/Landing			
No. Flights	< 1	≥ 1	≥ 2	≥ 3	< 1	≥ 1	≥ 2	≥ 3
5 or less	.12	.73	.13	.03	.55	.37	.07	.01
6/7	.24	.66	.09	.01	.58	.37	.04	.01
8 or more	.43	.55	.02	.00	.55	.40	.04	.01

[1]The large proportion of <1 deviations in the penetration/approach/landing segment is due to the large number of observations of glide slope and course line deviations (up to 12 for each approach).

Another way to look at the skill acquisition process is to look at comments made by the IP. Table 7 presents a summary of such comments in terms of the number of pilots/copilots receiving a negative comment as a function of the number of flights on the T-39B for various mission segments. The comments were categorized in terms of the area of flight to which they applied and then tabulated. The low number of comments on bombing/visual contour reflects to some extent the limited number of missions on which it was accomplished. Also, the lack of comments on the takeoff/climb/level-off/cruise portion in the early flights (No. 1 through 4) may be partly due to the source. Data were collected from comments on the flight records only for these early flights, since they occurred before the rating forms were used. Nonetheless, a clear general pattern emerges. Penetration/approach/landing persists as the area of greatest difficulty throughout the range of number of missions accomplished by pilots/copilots in this test.

Table 7. **Number of Pilots/Copilots Receiving a Negative Comment Concerning Particular Mission Activities as a Function of T-39B Flight Number**

	T-39B Flight Number										
T-39B Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Takeoff/Climb/Level-Off/Cruise											
Procedure			1		4	2	2		2		
Technique			1	1	2	5	1	2	1		
Airspeed					1	3			1		
Altitude				1	1	1					
Heading						1			1		
Crew Coordination and Communication											
Bombing/Visual Contour											
Procedure					1		1				
Technique						1	1				
Airspeed					1	1	1				1
Altitude						2	1				
Heading											
Crew Coordination and Communication				1							
Penetration/Approach/Landing											
Procedure	6	1	2	2	7		4	4	2	1	
Technique	2	2	3		3	2	4	1	2		
Airspeed	3	2	2	3	3	1	3	1		1	1
Altitude	5	2	3	1	4		3	3	1	1	1
Heading	5	1	5	2	4	3	3	2	2		1
Crew Coordination and Communication							1	1			
Go Arounds											
Procedure	1		1			1	3			1	
Technique	4	1	3		1	1	3				
General											
Control Inputs	8	4	3	6	5	4	4	2	2		
System Operation	2	1	3		1	2	2	2	1		
Airspeed				2		1				1	

As in the T-39A data, of interest are the areas which show persistent problems across individuals. In considering those errors that occurred on more than one flight for a particular pilot/copilot and which were committed by more than one pilot/copilot, three problems emerge. First, the use of abrupt, choppy control inputs like those used in the B-52. Second, directional control problems or crab in landing occur. The B-52 can be landed in a crab because of the turnable trucks. Third, some pilots/copilots use a fast rate on climb out after takeoff. Again, the B-52 requires a faster rate of climb than does the T-39. It appears, then, that the most general and persistent problems are those which are related to habits developed in the B-52.

A final factor affecting T-39B performance was the time between flights. Because of their normal duties, some crews had delays between T-39B flights of more than 30 days. This would be a critical aspect of a CTA program. Remaining proficient in the CTA requires that the crews fly at regular intervals. How long could those intervals be? The data in Table 8 provide some indication, at least for pilots/copilots at the level of skill acquired in this test. Table 8 presents the pattern of tolerance deviations as a function of number of days since the last flight in the T-39B. The data are arranged in three categories: (a) 0 days, or the second flight on a particular day, (b) 1 to 14 days, and (c) 15 or more days. The mean scores associated with these three categories were 3.35, 3.34, and 3.12, respectively. A Wilcoxon test on the difference between 1 to 14 days and 15 or more days was significant ($p < .05$). Basically, there is an increase in the proportion of tolerance deviations ≥ 1 or greater in the 15 or more days group. That is, more variability in performance occurs.

Table 8. **Proportions of T-39B Tolerance Deviations as a Function of Days Since Last T-39 Flight**

Days	Tolerance Deviations < 1	≥ 1	≥ 2	≥ 3
0	.43	.50	.06	.01
1 – 14	.45	.45	.08	.01
15 or more	.32	.52	.11	.05

Interview Data

The results of the interviews with the crews can be most easily discussed by considering the responses to each of the eight topics separately.

1. *Overall impressions of the program.* The general response of the pilots was that it was fun to fly the T-39B, but that the radar was a problem for the crew. Because of the very different radar unit, crew coordination was not like that which occurs in the B-52. The chance to practice instrument procedures was useful, particularly in different aerodromes. In fact, the chance to practice strange field procedures and other diversification aspects of the program, e.g., new routes, seemed to be its most positive contribution. However, due to scheduling problems, only a few of the crews were able to use this capacity to fly to different fields and then return. Copilot responses mirrored those of pilots. They felt that T-39B activity was good for proficiency flying and for diversification. However, differences in checklists and the lack of time pressures like those in the B-52 apparently affected crew coordination aspects of the mission, such that they were not like the primary aircraft. Pilots and copilots both felt that in general, the cockpit design was excellent.

Radar navigators and navigators generally had a negative response to the test. Most of them felt that the navigation equipment in the T-39B was too different from the B-52 to provide any training and was in fact difficult to operate. Because of limited radar capabilities, the role of the navigator and radar navigator were reversed in the T-39B, the INS providing primary navigation information with the radar as a backup only. Although diversification was enjoyable, both the radar navigator and navigator had little to do in the T-39B due to equipment differences.

2. *Changes which they would have made in the program.* Pilots and copilots would have made few changes to the test program. Longer range for the test aircraft would have been desirable. Also, they stated that the mission scenario should have been even more like the B-52 so that crew coordination would have been more of a requirement. This would have basically involved using a different radar, which was the main point made by radar navigators and navigators. They felt that a better radar was needed, but given the R-14C, more could have been accomplished if the resolution had simply been better. The poor resolution, as compared to the B-52, made it difficult to identify and track offsets, which is the primary means of navigation in the B-52.

3. *What, if any, training occurred.* Both pilots and copilots felt that the T-39B provided useful practice in instrument procedures. This included the chance for aerodrome diversification. The increased air time may also have benefitted basic airmanship. Copilots had an excellent opportunity to practice visual navigation and map interpretation in coordination with the navigators. This is an activity for which they receive little practice in the B-52 and is an important backup mode of operation.

Radar navigators and navigators felt that they received little training in the T-39B. The basic problem was the limitations of the R-14C. Radar scope interpretation was possible for experienced individuals such as the radar navigators, but was difficult and of little utility for navigators. The training that was possible in basic navigation and target direct bombing was difficult to relate to the B-52 because a completely different way of thinking was involved.

4. *Specific problems in the B-52 or the T-39.* No specific operational problems of significance were identified by any of the crew members. One radar navigator, after flying in the T-39B, mentioned a tendency to turn the map to match the line-of-flight in the B-52. One copilot suggested that the slower pacing in the T-39B might mislead one into going too slow in the B-52, where the procedures are more complex and much more numerous. The differences between the T-39 and B-52 did cause some discomfort. Most of the radar navigators and navigators suffered at least one case of airsickness. This may have been due in part to unsatisfactory air conditioning in the rear compartment of the T-39. However, the difference in susceptibility to turbulence is clearly an issue that must be considered in the use of a CTA. It may be necessary to limit operations to only mildly turbulent conditions, as was done in this test.

5. *Probable success of a CTA program, given better equipment.* All of the crew members felt that with the right equipment, a CTA program could provide excellent training. If there were any problems, they would occur for very inexperienced crew members, i.e., new copilots and navigators. The chance for diversification would even provide added incentive in training. The shorter, more task intensive training flights would also be good.

6. *Additional equipment which would be necessary in a CTA.* Over and above the equipment in the T-39B, pilots and copilots felt that the CTA would need some form of terrain trace so that terrain avoidance could be practiced. Displays similar to those on the B-52 system might even be useful so as to provide practice on current procedures. Radar navigators and navigators felt that an offensive system like that on the B-52 is necessary, so as to provide effective cross training.

7. *What could/could not be training in a CTA.* With the proper equipment, pilots and copilots thought that instrument procedures, low level flight, and crew coordination could all be trained on a CTA. The only major training event which everyone agreed could not be trained on the CTA was air refueling. Air refueling rendezvous could be trained, however. Radar navigators and navigators agreed that with equipment which replicates the B-52, all of their training events could be accomplished in a CTA.

8. *Scheduling, for the test program and for a CTA.* Scheduling was one of the main problems for the concept test. Since B-52 flying was not significantly reduced, T-39B flights were scheduled whenever time was available, including mission planning days for the B-52. The crews felt that such reductions in mission planning time and the generally heavy flying schedule were detrimental. The original scheme to cut B-52 flying and so provide entire days for T-39B flying would have been better, in their opinion. As far as a CTA program is concerned, the most frequent comment was that a good intermix of CTA and B-52 flying would be needed. One would need to fly the CTA at least every couple of weeks to stay proficient in that aircraft. B-52 flying could probably be reduced, at least to nine sorties a quarter if not less, and the CTA could be flown in its place.

IV. DISCUSSION

Before discussing the results of this test, it would be appropriate to once again consider the limitations which affect their utility and interpretation. The cancellation of the CTA program had three major effects on the test. First, it limited data collection to the test group only. The lack of a monitored group critically affects the interpretation of the B-52 data. The results that were found could simply be due to changes normally occurring over time or to adaptation to the test environment. At best, the data could reveal whether dual qualification had any immediate, marked negative effects on primary aircraft performance. This relates directly to the second effect of program cancellation, i.e., the short duration of the test. Since the crews had only 2 months to fly integral missions in the T-39B, the data could only reveal short-term effects on performance. The long term effects of dual qualification, both in terms of primary aircraft performance and secondary aircraft skill acquisition, could not be determined. Some projections concerning the latter may be possible, but they must be stated with reservation. The third effect on the test of CTA cancellation concerned the skill maintenance issue. Since B-52 flying time was not reduced, training in the T-39B served not for skill maintenance, but rather as added practice. It did not substitute for B-52 training. If there were positive effects on performance, they may have come from the overall increase in training time when T-39B training was introduced. Such effects may indeed indicate that

T-39B training served as an effective supplement to B-52 training, but they do not allow the conclusion that such training could compensate for reductions in B-52 activity. Also, there is certainly no evidence from the test to indicate the relationship between B-52 and T-39B training, i.e., how much T-39B training would equal a certain amount of B-52 training.

Two other factors which affect the conclusions concerning a possible CTA must be considered. First, the test had validity for pilots/copilots only. The pilot/copilot station appproximated what could be expected in a CTA quite accurately. The radar navigator and navigator stations did not. The R-14C radar was selected for use in the concept test aircraft due to cost, schedule, and availability considerations. It did not include radar features and capabilities like the B-52 or those planned for the CTA. This severely limits what can be said concerning radar navigator/navigator training. The second point to note is that the test was not performed in the context of a WST program. If flying time were reduced by use of the WST, it is not clear how further reductions and the introduction of a CTA would affect crew performance. Such an issue would have to be addressed in a completely separate test.

Despite this litany of limitations, what can the results of this test tell us? First, the B-52 performance data for pilots/copilots suggest that there were general improvements in performance. The data from flights before T-39 training began suggest that this was not simply due to adaptation to the test environment. The interview comments support the beneficial nature of T-39B training as well. Most of the pilots and copilots felt that it was fun to fly the T-39 and that it was particularly beneficial in practicing instrument/pattern procedures. The copilots felt that the training was also useful in the area of visual navigation, which involves crew coordination with the radar navigator/navigator.

Radar navigator and navigator data were too limited to provide any useful information. Since the T-39B navigation equipment was unlike anything in the B-52 or the proposed CTA, such information would have had no direct bearing on the likelihood of success with a CTA training program anyway. Past experience with simulation suggests that with a high fidelity system a CTA could be an effective trainer. Indeed, the general feeling of the radar navigators/navigators in the test group was that with the right equipment, it would not matter which aircraft they were flying.

The dual qualification data from the T-39 for pilots/copilots is easier to interpret. Both the T-39A and T-39B data reveal that approach and landing is the most difficult phase of T-39 training and shows the slowest progression in learning. In fact, over the range of number of flights in the T-39B experienced in this test, no significant improvement in performance occurred in the approach and landing phase. This compares to the progression in aircraft handling in the takeoff/climb/level-off phase. The clear implication for any CTA program is that training must be concentrated on the landing phase. It is the phase where B-52 habits are most inappropriate and could be dangerous. Although no safety of flight problems actually occurred in this test, this is where they could happen.

The data on the effect of delays between flights in the T-39B also have implications for a CTA program. During initial skill acquisition in the secondary aircraft, it is necessary to have frequent, regular flights. In this test, every 2 weeks seemed to be a reasonable schedule. Longer periods of time resulted in performance decrements. Frequencies of once a week or once every 2 weeks would appear to be reasonable, at least early in any CTA program.

The results of this test can also be compared to those from Project Constant Growth (Kantor, Noble, & Reid, 1977) and the Accelerated Copilot Enrichment (ACE) survey (Eickhoff, 1977). In both of those studies, there were mixed results of secondary aircraft flying on self-perceived primary aircraft performance. Both beneficial and detrimental effects were found. This compares to the present results where neither performance data nor crew reports revealed any problems in the primary aircraft. The other two studies did not concern themselves with performance in the secondary aircraft. The differences in the results may arise from a number of sources. First, there were differences in the secondary aircraft used. The T-39, according to the pilots/copilots in this test, is a simple aircraft to fly. The ease with which it could be learned could have contributed to its lack of effect on primary aircraft performance. Second, and perhaps more importantly, this test was completed over a much shorter time period than the other two studies. This meant that there was less time in which decrements in primary aircraft performance could develop as secondary aircraft skill increased. Additionally, the low level of secondary aircraft skill may itself have contributed to the lack of effects. Until strong habits were developed in that aircraft, they would be unlikely to start impinging on primary aircraft habits. Third, the regime in which the secondary aircraft was flown may be important. In Constant Growth and ACE, no attempt was made to fly primary aircraft type missions in the secondary aircraft. The latter was used purely for general flying skill development.

In this test, the T-39B missions were designed to be as similar as possible to B-52 missions. Many of the same procedures were practiced, so this may have avoided the problem of using different procedures. Finally, and this relates directly to the previous point, in this test the T-39B instrument panel was modified to reflect B-52 instrumentation as much as possible. No such modification occurred in the other two studies. Part of the problems encountered in those studies may have arisen from conflicting scan patterns or trouble in using different instruments. Returning to the primary aircraft may have required some readjustment. This could have led to slower responding by the operator and a feeling of decreased performance. Each of these factors may have contributed to the differences in the results. Nonetheless, all three studies reveal some benefit of secondary aircraft training on primary aircraft training on primary aircraft performance. This obviously bodes well for a possible CTA program.

The test results can also be considered in the light of transfer of training predictions for pilots/copilots. Basically, positive transfer was expected in similar stimulus situations where responses trained in one aircraft were appropriate in the other, negative transfer where such responses were inappropriate. The B-52 data and pilot/copilot comments concerning instrument procedures all seem to indicate positive transfer effects, as predicted. Although no negative transfer was noticed in the B-52, there was some in the T-39. Both in T-39A and T-39B training, there were areas where B-52 habits affected T-39 performance, such as in rough aircraft handling. This also is in accordance with the predictions. Although the evidence is meager, the expected mixture of results was obtained. Two questions arise from this. First, as skill increases in the secondary aircraft, would more or less negative transfer between aircraft occur? Second, even if some negative transfer occurred, would the benefits outweigh the problems incurred? This test does not provide the answers to these questions.

One of the positive aspects of the test was the success of the data collection procedures developed for the B-52 and T-39. Although there was some problem in the ratings due to evaluator differences, in general the measures were effective. They were sensitive enough to detect differences which were predictable (e.g., pilots vs. copilots), as well as ones which were not (e.g., the effect of days between flights on T-39B performance). This suggests they could be profitably employed in other contexts.

Finally, the results from the interviews were generally supportive of the CTA concept. With adequate offensive stations and a terrain trace, most crews felt that a CTA could provide excellent training. None of the pilots or copilots felt that flying a second aircraft hurt their B-52 performance. The problem with the test aircraft basically resided in the lack of a good radar. Scheduling was a problem because the T-39 flying was simply added on to an already busy B-52 flying schedule. At times there were long delays between T-39 flights. In a CTA program, there would have to be clear reductions in B-52 activity and regularly scheduled CTA flights.

In summary, the results of the test were affected by a number of critical factors. This meant that only limited objectives could be addressed. The clearest results concerned the process of dual qualification in the T-39. The number of flights accomplished and the amount of time between flights affected pilot and copilot performance in the T-39. The limited data available on the impact of the program on B-52 performance revealed no negative effects. The general reaction of the crews to the CTA concept was positive. Their reaction to the test was colored by inherent limitations in the equipment and scheduling difficulties.

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Table A-1. **Self Assessments of T-37/T-38 Training Impact on Primary Aircraft Performance (Project Constant Growth)**

Performance Area	Beneficial %	No Impact %	Detrimental %	N/A %
C-141 Copilots (n = 27)				
Instrument flying	44	33	22	0
Weapons delivery	0	19	7	74
Operating procedures	0	37	59	4
Formation flying	0	14	4	82
Aircraft handling	15	33	52	0
Crew coordination	15	74	11	0
Staying ahead of Unit Equipment (UE)	22	48	30	0
Overall UE performance	41	18	41	0
F-111D Pilots (n = 25)				
Instrument flying	24	60	16	0
Weapons delivery	4	72	16	8
Operating procedures	8	44	48	0
Formation flying	56	28	16	0
Aircraft handling	28	36	36	0
Crew coordination	8	50	42	0
Staying ahead of UE	24	68	8	0
Overall UE performance	24	52	24	0
F-4E Pilots (n = 14)				
Instrument flying	43	50	7	0
Weapons delivery	0	83	0	17
Operating procedures	0	69	31	0
Formation flying	38	54	8	0
Aircraft handling	0	100	0	0
Crew coordination	0	69	23	8
Staying ahead of UE	0	92	8	0
Overall UE performance	15	69	16	0

Table A-2. **Assessments by Participating Copilots and Their Aircraft Commanders of ACE Program Impact on Primary Aircraft Performance**

Performance	Copilots			Aircraft Commanders		
	Beneficial %	No Impact %	Detrimental %	Beneficial %	No Impact %	Detrimental %
Instrument procedures	91	7	3	93	6	1
Precision approaches	84	14	3	85	12	4
Non-precision approaches	84	15	2	86	13	1
Takeoff	47	51	2	48	51	1
Landing	45	35	21	35	34	31
Air refueling	28	72	1	31	69	0
Navigation	76	24	1	76	25	0
Low Level	83	18	0	43	57	0
Communications	78	22	0	83	16	1
Inflight planning	83	18	0	82	17	1
Cross check	89	9	2	87	9	4
Strange field procedures	95	5	0	86	14	1
Crew coordination	58	41	1	62	32	7
Overall performance	93	5	3	88	8	4

APPENDIX B: B-52 DATA COLLECTION FORMS

CONCEPT TEST DATA FORM

Crew Number ________ Date ________ Flt.# ________

P ________ ________

CP ________ ________ T.O. ________

RN ________ ________ Duration ________

N ________ ________ Landing ________

EW ________ ________

G ________ ________ Evaluator ________

Mission Summary A/R ________ L/L ________ TA Yes___ No___	STR Activity Site ________ # Runs ________ Time(s) ________
Tail# ________ WX:	ECM Yes___ No___ Type: ODR___ MDR___ TDR___ Comments:
Remarks:	

1

	P	CP
PRETAKEOFF		
Procedure	E S M U	E S M U
Cockpit Instrument Check	E S M U	E S M U
TAKEOFF (P___ CP___)		
Water injection Yes___ No___		
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U
Tolerances		

S_1 — E S M U

Centerline — VL L ↑ R VR

S_2 (Planned:___) — -10 -5 0 +5 +10

Gear retraction — Pos Not Pos

Wing rock — Excessive Some None

Start Flap (KIAS) — 165 170 180 190 195

Min. Alt. 1000ft. — Yes___ No___

50% Flap (KIAS) — 185 190 200 210 215

30% Flap (KIAS) — 195 200 210 220 225

Flap full up (KIAS) — 215 220 230 240 245

WX: RVR ________ VIS ________ X-Wind Crab ________

Air: Rough___ Smooth___

Comments:

Figure B-1. **B-52 Pilot/copilot data form.**

2

CLIMB/INSTRUMENT DEPARTURE (P___ CP___)

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U
Communications	E	S	M	U	E	S	M	U

Tolerances

Airspeed (KIAS)	-15 -10 -5 0 +5 +10 +15
Heading (degrees)	-9 -6 -3 0 +3 +6 +9
Intermediate L/O Alt. (ft.)	-300 -200 -100 0 +100 +200 +300
Navigation (degrees)	-9 -6 -3 0 +3 +6 +9

WX: IMC___ VMC___ Air: Rough___ Smooth___ Drift___

Comments:

3

LEVEL-OFF (P___ CP___)

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U

Tolerances

Airspeed (KIAS)	-15 -10 -5 0 +5 +10 +15
Heading (degrees)	-9 -6 -3 0 +3 +6 +9
L/O Alt. (ft.)	-300 -200 -100 0 +100 +200 +300
Navigation (degrees)	-9 -6 -3 0 +3 +6 +9

WX: IMC___ VMC___ Air: Rough___ Smooth___

Comments:

CRUISE

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Autopilot Operation	E	S	M	U	E	S	M	U
Inflight TA Check	E	S	M	U	E	S	M	U
TAS Check	E	S	M	U	E	S	M	U
BNS Check	E	S	M	U	E	S	M	U
Station Check	E	S	M	U	E	S	M	U
Engine Data	E	S	M	U	E	S	M	U
DCE	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U
Communications	E	S	M	U	E	S	M	U

Comments:

Figure B-1. **B-52 Pilot/copilot data form (*Continued*)**

4

AIR REFUELING (P___ CP___)	P	CP
Procedures	E S M U	E S M U
Breakaway Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U

Tolerances:

Rate of descent (fpm)	___ -750 -500 -250 0 +250 +500 +750 ___
Descent airspeed(KIAS)	___ -15 -10 -5 0 +5 +10 +15 ___
L/O to 1 mile	
Airspeed (KIAS)	___ -15 -10 -5 0 +5 +10 +15 ___
Altitude (ft)	___ -300 -200 -100 0 +100 +200 +300 ___
L/O to 1/2 mile	
Airspeed (KIAS)	___ -15 -10 -5 0 +5 +10 +15 ___
Altitude (ft)	___ -300 -200 -100 0 +50 +100 +150 ___

Contact time (min)___ Onload (lbs)___
Inadvertent disconnects (no.)___
Auto pilots: B-52 on___ off___ KC-135 on___ off___

Lighting	Day	Dusk		Night	Too Dark
Visibility	Nil	Poor	Fair	Good	Excellent
Turbulence	None	Occ. Lt.	Lt.	Occ. Mod.	Mod.
Tanker Platform	Poor	Fair	Good		Excellent

Comments:

5

HOLDING (P___ CP___)	P	CP
WX: IMC___ VMC___ Air: Rough___ Smooth___		
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Communications	E S M U	E S M U
Tolerances		
Airspeed (KIAS)	___ -15 -10 -5 0 +5 +10 +15 ___	
Altitude (ft)	___ -300 -200 -100 0 +100 +200 +300 ___	
Time (min)	___ -3 -2 -1 0 +1 +2 +3 ___	
Navigation (degrees)	___ -9 -6 -3 0 +3 +6 +9 ___	

PENETRATION/LET DOWN (P___ CP___)

Enroute Descent ___ Published penetration: L/L ___ IAP ___

	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U
Tolerances		
Airspeed	___ -15 -10 -5 0 +5 +10 +15 ___	
Altitude		
Start of pen. turn	___ -900 -600 -300 0 +300 +600 +900 ___	
Other times	___ -150 -100 -50 0 +50 +100 +150 ___	
Heading (degrees)	___ -9 -6 -3 0 +3 +6 +9 ___	

WX: IMC ___ VMC ___ Air: Rough ___ Smooth ___

Comments:

Figure B-1. **B-52 Pilot/copilot data form (*Continued*)**

6

MISSED APPROACH (P___ CP___)	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U

Tolerances

Climb/Level-off Airspeed (KIAS) -15 -10 -5 0 +5 +10 +15

Level-off Altitude (ft) -300 -200 -100 0 +100 +200 +300

Heading (degrees) -9 -6 -3 0 +3 +6 +9

EMERGENCY PROCEDURES

6-engine ___ Flaps-up ___ 7-engine T.O. ___ Other ______

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U

Comments:

7

APPROACH (P___ CP___)	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U
Communications	E	S	M	U	E	S	M	U

Tolerances

BF______ Pattern Type: A/B-4___ 6-Engine___ Flaps-up___

Pattern (VIS___ TACAN___ VOR___ ILS___ LOC___ ASR___ PAR___)

Airspeed (KIAS) -15 -10 -5 0 +5 +10 +15

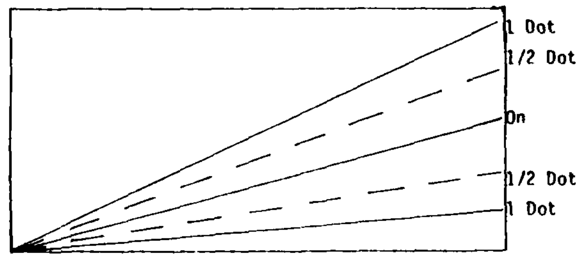
Altitude (ft) -200 -150 -50 0 +50 +150 +200

Heading (degrees) -9 -6 -3 0 +3 +6 +9

Final Approach

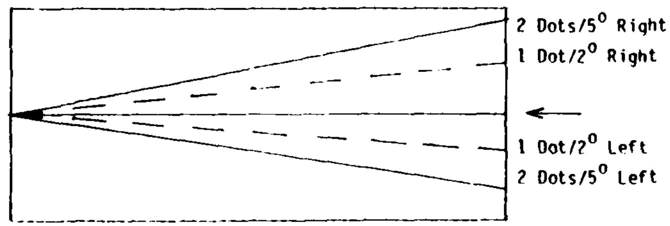
Drift____ Wind_____ WX_________ Vis_____ Turb_____

Glide Slope



Range (NM) 1 2 3 4 5 6

Course Line



Range (NM) 1 2 3 4 5 6

Airspeed: __ __ __ __ __ __

Figure B-1. **B-52 Pilot/copilot data form** (*Continued*)

8

PRELANDING/LANDING (P ___ CP ___)

	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U

Best Flare (KIAS) ______ X-Wind Crab ______

Prelanding

Centerline: Well Left — Slightly Left — ↑ — Slightly Right — Well Right

Airspeed at threshold (KIAS): ___ -10 -5 BF +5 +10 ___

Flare Height: Low — OK — High

Wing Rock: Excessive — Some — None

Landing

T.D. Airspeed (KIAS) ___

T.D. Point: 1st Brick — 1000 — 2000 — 3000 — 4000 (ft)

T.D. Firmness: 781 — Tooth Loosener — Hard — Mod. — Grease Job

T.D. Centerline: Well Left — Slightly Left — ↑ — Slightly Right — Well Right

Drag Chute: Early — Prompt — Late

Air Brakes: Early — Prompt — Late

Brakes: Early — Prompt — Late

Comments:

9

BOMBING (P ___ CP ___)

Type: Sync ___ Alt ___ Vis ___ Time of Release: ______

	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U

Tolerances

Airspeed (KIAS): ___ -15 -10 -5 0 +5 +10 +15 ___

Heading (degrees): ___ -6 -4 -2 0 +2 +4 +6 ___

Altitude (ft): ___ -300 -200 -100 0 +100 +200 +300 ___

FCI Deflection: ___ Left 9 6 3 0 3 6 9 Right ___

WX: IMC ___ VMC ___ Air: Rough ___ Smooth ___

Comments:

LOW LEVEL NAVIGATION

	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U

Tolerances

Airspeed (KIAS):
P ___ -15 -10 -5 0 +5 +10 +15 ___
CP ___ -15 -10 -5 0 +5 +10 +15 ___

Altitude (ft):
P ___ -300 -200 -100 0 +100 +200 +300 ___
CP ___ -300 -200 -100 0 +100 +200 +300 ___

Heading (degrees):
P ___ -6 -4 -2 0 +2 +4 +6 ___
CP ___ -6 -4 -2 0 +2 +4 +6 ___

WX: IMC ___ VMC ___ Air: Rough ___ Smooth ___

Comments:

Figure B-1. **B-52 Pilot/copilot data form** (*Continued*)

10

	P	CP
TERRAIN AVOIDANCE		
Tilt error ____ Bias error ____		
TA Calibration Check	E S M U	E S M U
EVS Use	E S M U	E S M U
Procedures	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Tolerances:		

Tolerances		Scale
Heading (degrees)	P ____	-12 -8 -4 0 +4 +8 +12 ____
	CP ____	-12 -8 -4 0 +4 +8 +12 ____
Crossing Altitude (ft)	P ____	-150 -100 -50 0 +100 +200 +300 ____
	CP ____	-150 -100 -50 0 +100 +200 +300 ____
Airspeed (KIAS) Flat or rolling	P ____	-15 -10 -5 0 +5 +10 +15 ____
	CP ____	-15 -10 -5 0 +5 +10 +15 ____
Mountainous	P ____	-30 -20 -10 0 +10 +20 +30 ____
	CP ____	-30 -20 -10 0 +10 +20 +30 ____

Comments:

EQUIPMENT OPERATION	
Fuel System	E S M U
Hydraulics	E S M U
Engines	E S M U
Radios	E S M U
Electical	E S M U
Terrain Avoidance	E S M U

Comments:

Figure B-1. **B-52 Pilot/copilot data form (*Concluded*)**

1

	RN	N	Comments
PREFLIGHT			
Proc./Checklists	E S M U	E S M U	
AFTER ENGINE START/ BEFORE TAKEOFF			
Pro./Checklists	E S M U	E S M U	
Crew Coordination	E S M U	E S M U	
TAKEOFF			
S_1 timing (secs)		-2 -1 0 +1 +2	
Proc./Checklists	E S M U	E S M U	
SRAM POWER ON			
Proc./Checklists		E S M U	
CLIMB			
Proc./Checklists	E S M U	E S M U	
LEVEL OFF			
BNS Set	E S M U		
TAS Check		E S M U	
BNS CHECK			
Proc./Checklists	E S M U	E S M U	
Crew Coordination	E S M U	E S M U	
SRAM INITIALIZATION			
Proc./Checklists	E S M U	E S M U	
TA FUNCTIONAL CHECK			
Proc./Checklists	E S M U	E S M U	

Figure B-2. **B-52 Radar navigator/navigator data form.**

2

	RN	N	Comments
AIR REFUELING RENDEZVOUS			
(Type:_______________)			
Establish ID	Yes No		
Computations(NM)	0 1 2 3 4 5		—
Execution(NM)	0 1 2 3 4 5		—
Crew Coordination	E S M U		
Communications	E S M U		
MISSILE POWER			
Proc./Checklists		E S M U	
TARGET/OFFSET VERIF.			
AOU	E S M U		
SRAM		E S M U	
WP SR/MP SR			
Proc./Checklists	E S M U	E S M U	

3

	RN	N	Comments
BEFORE DESCENT			
Proc./Checklists	E S M U	E S M U	
Crosscheck Ballistics			
ATF (sec)	0 .4 .8 1.2		—
Trail (ft)	0 600 1200 1800 2400		—
Alternate/ETPTG (sec)	0 3 6 9		—
Ballistics Derivatives (divisions)	0 1 2		—
Course/Bearing (degrees)	0 2 4 6		—
Time from TIP to release (sec)	0 3 6 9		—
Time between targets (sec)	0 3 6 9		—
PECP			
Timing (sec)		-2 -1 0 +1 +2	—

Figure B-2. **B-52 Radar navigator/navigator data form (*Continued*)**

4

	RN	N	Comments
DESCENT			
Proc./Checklists	E S M U	E S M U	
TA CALIBRATION			
Proc./Checklists	E S M U	E S M U	
Calibration Altitude (ft)	0 100 200	0 100 200	
Determine System err.			
Tilt error (deg)		0 .25 .5 .75 1	
Bias Error (ft)		0 100 200 300	
Update FRL (deg)		0 .25 .5 .75 1	
Terrain Clearance	E S M U		
MISSILE PRE-LAUNCH			
Proc./Checklists		E S M U	
BEFORE IP			
Proc./Checklists	E S M U	E S M U	
POST LAUNCH			
Proc./Checklists	E S M U	E S M U	
POST RELEASE			
Proc./Checklists	E S M U	E S M U	
LOW ALTITUDE NAV.			
Proc./Checklists	E S M U	E S M U	
Mission Data Recording	E S M U	E S M U	
Centerline Deviations (NM)		0 2 4	
Release times (min)		-3 -2 -1 0 +1 +2 +3	

5

	RN	N	Comments
BEFORE DESCENT			
Proc./Checklists	E S M U	E S M U	
DESCENT/LANDING			
Proc./Checklists	E S M U	E S M U	
AFTER LANDING			
Proc./Checklists	E S M U	E S M U	
CREW COORDINATION	E S M U	E S M U	
EMERGENCY PROCEDURES	E S M U	E S M U	
EQUIPMENT OPERATION			
Proc./Checklists	E S M U	E S M U	
Present Position			
Counters Errors (NM)	0 10 20 30		
Malfunction Analysis	E S M U	E S M U	
Malf. Compensation	E S M U	E S M U	
Malf. Correction	E S M U	E S M U	
SRAM PROGRAMMING			
Proc./Checklists	E S M U	E S M U	
Crew Coordination	E S M U	E S M U	
Crosshair Placement (ft)	0 1000 2000 3000		
OXYGEN STATION			
Proc./Checklists	E S M U	E S M U	

Figure B-2. **B-52 Radar navigator/navigator data form (*Concluded*)**

6

GENERAL NAVIGATION	RN	N	Comments
Proc./Checklists	E S M U	E S M U	
Mission Data Recording	E S M U	E S M U	
Grid Entry/Exit	E S M U	E S M U	
Course Deviations (NM)		0 5 10 15 20	
Air Refueling Time (min)		-2 -1 0 +1 +2	
High Release Time (min)		-2 -1 0 +1 +2	
Low Entry Control Time (min)		-2 -1 0 +1 +2	

7

				Synchronous			Alternate				SRAM
Rel #	Rel Type	Rel Time	Tgt	X-hair placement (1000's ft)	Release heading error (degrees)	SRAM update	ETP error (1000's ft)	Release heading error (degrees)	Release actuation time error (min)	Heading to release computation error (degrees)	Procedures and checklists
1						Y N					E S M U
2						Y N					E S M U
3						Y N					E S M U
4						Y N					E S M U
5						Y N					E S M U
6						Y N					E S M U
7						Y N					E S M U
8						Y N					E S M U
9						Y N					E S M U
10						Y N					E S M U

Figure B-2. **B-52 Radar navigator/navigator data form** (*Concluded*)

APPENDIX C: T-39B DATA COLLECTION FORMS

P/CP TEST DATA FORM

Crew Number ________ Date ________ Mission # ________
P ________ T.O. (Z) ________
CP ________ Landing (Z) ________
4950 IP ________ Tail # ________

Mission Summary:
A/R RZ yes ____ no ____
Visual Contour yes ____ no ____
No. of Approaches ________

Maintenance Comments:

Overall Comments:

2

	P	CP
PRETAKEOFF		
Procedure	E S M U	E S M U
Cockpit Instrument Check	E S M U	E S M U
TAKEOFF (P___ CP___)		
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Tolerances		
Centerline	VL L ↑ R VR	
Rotation Speed	-10 -5 0 +5 +10	
Take off Attitude	Low OK High	
Gear retraction	Pos Not Pos	

WX: RVR ________ VIS ________ X-Wind ________

Comments:

Figure C-1. **T-39B Pilot/copilot data form.**

CLIMB/INSTRUMENT DEPARTURE (P____ CP____)	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U
Tolerances		
Airspeed (KIAS)	-15 -10 -5 0 +5 +10 +15	
Heading (degrees)	-9 -6 -3 0 +3 +6 +9	
Intermediate L/O Alt. (ft.)	-300 -200 -100 0 +100 +200 +300	
Navigation (degrees)	-9 -6 -3 0 +3 +6 +9	

WX: IMC____ VMC____ Air: Rough____ Smooth____ Drift____

Comments:

LEVEL-OFF (P ___ CP ___)	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Tolerances		
Airspeed (KIAS)	-15 -10 -5 0 +5 +10 +15	
Heading (degrees)	-9 -6 -3 0 +3 +6 +9	
L/O Alt. (ft.)	-300 -200 -100 0 +100 +200 +300	
Navigation (degrees)	-9 -6 -3 0 +3 +6 +9	

WX: IMC____ VMC____ Air: Rough____ Smooth____

Comments:

CRUISE	P	CP
Procedures	E S M U	E S M U
Cruise Check	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U

Comments:

Figure C-1. **T-39B Pilot/copilot data form** (*Continued*)

5

AIR REFUELING RENDEZVOUS (P_____ CP_____)

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U
Communications	E	S	M	U	E	S	M	U

VIS_____________ WX_____________ Air: Rough______ Smooth____

Comments:

6

BOMBING (P ____ CP ____)

Type: Alt ____ Vis ____ Time of Release:______________

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U
Communications	E	S	M	U	E	S	M	U

Tolerances

	P	Scale	CP
Airspeed (KIAS)	____	-15 -10 -5 0 +5 +10 +15	____
Heading (degrees)	____	-6 -4 -2 0 +2 +4 +6	____
Altitude (ft)	____	-300 -200 -100 0 +100 +200 +300	____

WX: IMC ____ VMC ____ Air: Rough ____ Smooth ____

VISUAL CONTOUR

	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U

Tolerances:

		Scale	
Heading (degrees)	P____	-12 -8 -4 0 +4 +8 +12	____
	CP____	-12 -8 -4 0 +4 +8 +12	____
Crossing Altitude (ft)	P____	-150 -100 -50 0 +100 +200 +300	____
	CP____	-150 -100 -50 0 +100 +200 +300	____
Airspeed (KIAS) Flat or rolling	P____	-15 -10 -5 0 +5 +10 +15	____
	CP____	-15 -10 -5 0 +5 +10 +15	____
Mountainous	P____	-30 -20 -10 0 +10 +20 +30	____
	CP____	-30 -20 -10 0 +10 +20 +30	____

WX: IMC____ VMC____ Air: Rough____ Smooth____

Comments:

Figure C-1. **T-39B Pilot/copilot data form (*Continued*)**

7

HOLDING (P____ CP____)	P	CP
WX: IMC____ VMC____ Air: Rough____ Smooth____ Wind______		
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Communications	E S M U	E S M U
Tolerances		
Airspeed (KIAS)	-15 -10 -5 0 +5 +10 +15	
Altitude (ft)	-300 -200 -100 0 +100 +200 +300	
Time (min)	-3 -2 -1 0 +1 +2 +3	
Navigation (degrees)	-9 -6 -3 0 +3 +6 +9	

PENETRATION/LET DOWN (P____ CP____)		
Enroute Descent ____ Published penetration: L/L ____ IAP ____		
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Communications	E S M U	E S M U
Tolerances		
Airspeed	-15 -10 -5 0 +5 +10 +15	
Altitude		
Start of pen. turn	-900 -600 -300 0 +300 +600 +900	
Other times	-150 -100 -50 0 +50 +100 +150	
Heading (degrees)	-9 -6 -3 0 +3 +6 +9	

WX: IMC ____ VMC ____ Air: Rough ____ Smooth ____

Comments:

8

MISSED APPROACH (P_____ CP_____)	P	CP
Procedures	E S M U	E S M U
Technique	E S M U	E S M U
Crew Coordination	E S M U	E S M U
Tolerances		
Climb/Level-off Airspeed (KIAS)	-15 -10 -5 0 +5 +10 +15	
Level-off Altitude (ft)	-300 -200 -100 0 +100 +200 +300	
Heading (degrees)	-9 -6 -3 0 +3 +6 +9	

EMERGENCY PROCEDURES

Engine out Appr. and go ____ Engine loss on T.O. ____ Engine Failure ____		
Procedures	E S M U	E S M U
Crew Coordination	E S M U	E S M U

Comments:

EQUIPMENT OPERATION		
Fuel System	E S M U	E S M U
Hydraulics	E S M U	E S M U
Engines	E S M U	E S M U
Radios	E S M U	E S M U
Electrical	E S M U	E S M U
Air Cond/Press	E S M U	E S M U
Anti-Ice Oper	E S M U	E S M U
Oxygen	E S M U	E S M U

Comments:

Figure C-1. **T-39B Pilot/copilot data form (*Continued*)**

9

APPROACH (P___ CP___)	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U
Crew Coordination	E	S	M	U	E	S	M	U
Communications	E	S	M	U	E	S	M	U

Tolerances

Final Approach Speed___ Single Engine___ Flaps Down ___ Min Run___

Pattern (VIS___ TACAN___ VOR___ ILS___ LOC___ ASR___ PAR___)

Airspeed (KIAS) ___ -15 -10 -5 0 +5 +10 +15 ___

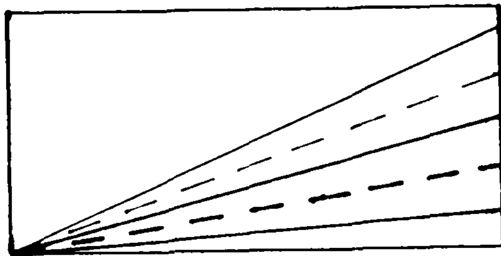
Altitude (ft) ___ -200 -150 -50 0 +50 +150 +200 ___

Heading (degrees) ___ -9 -6 -3 0 +3 +6 +9 ___

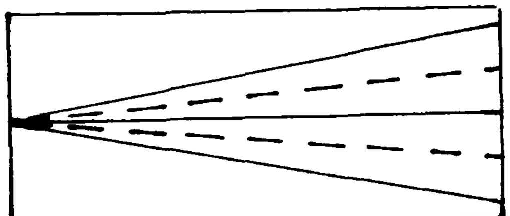
Final Approach

Drift___ Wind___ WX___ Vis___ Turb___

Glide Slope



Course Line



Airspeed: ___ ___ ___ ___ ___ ___

10

PRELANDING/LANDING (P___ CP___)	P				CP			
Procedures	E	S	M	U	E	S	M	U
Technique	E	S	M	U	E	S	M	U

Final Approach Speed (KIAS) ___ X-Wind ___

Prelanding

Centerline: Well Left — Slightly Left — ↑ — Slightly Right — Well Right

Airspeed at threshold (KIAS) ___ -10 -5 0 +5 +10 ___

Flare Height: Low — OK — High

Landing

T.D. Airspeed (KIAS) ___

T.D. Point: 1st Brick — 1000 — 2000 — 3000 — 4000 (ft)

T.D. Firmness: 781 — Tooth Loosener — Hard — Mod. — Grease Job

T.D. Centerline: Well Left — Slightly Left — ↑ — Slightly Right — Well Right

T.D. Az Angle: Left Crab — ↑ — Right Crab

Lateral Drift: Left Drift — ↑ — Right Drift

Raise Flaps: Early — Prompt — Late

Brakes: Early — Prompt — Late

Comments:

Figure C-1. **T-39B Pilot/copilot data form (*Concluded*)**

APPENDIX D: CTA ELECTRONIC WARFARE OFFICER STATION EVALUATION

The CTA concept of operations included provisions for a closed-loop simulation for electronic warfare officer (EWO) training. This EWO station would neither receive nor transmit signals external to the aircraft due to the weight involved in actual reception/transmission equipment. The system would present a variety of threat indications on appropriate displays and provide the capability for a full range of EWO responses. Threat presentations might even be linked to the aircraft navigation system so that appropriate effects of geographic features would occur (e.g., terrain masking) and threats would occur during appropriate mission segments (e.g., target penetration). This would provide a basis for increased crew coordination.

When the concept validation test of the CTA was originally designed, it included the evaluation of an EWO station developed by the Aeronautical Systems Division (ASD/ENETV). The primary purpose of this station was to demonstrate that the technology was available to construct a compact, lightweight trainer. The bulk of EWO training already takes place in a simulator, the AN/ALQ-T4, and the possibility of effective training via simulation was not in question. Two issues concerning the EWO station were important, however. First, could a system be built that would satisfy the size and weight constraints of the CTA? Second, what equipment would need to be simulated and at what level of fidelity in order to provide training?

ASD/ENETV consultations with representatives of HQ SAC and 1CEVG produced a list of the equipment that was most critical for training. Given time and size/weight constraints for the T-39B, the systems included in the active simulation were

1. ALR-20A Indicator and Control Panel
2. ALR-46 Control Indicator
3. ALQ-117 Monitor and Control Indicator
4. ALE-24 Programmer and Selector Control Panels
5. ALE-20 Flare Programming Control Panel
6. Master Expendables Control Panel (MEP)
7. Three ALQ-155 Control Indicator Programmers (CIPs)

These systems were capable of being operated by the EWO and provided interactive displays. Other systems appeared as dummy panels with knobs and dials but were not active.

Of particular interest among the above systems were the three ALQ-155 CIPs. Although the ALQ-155 system has been installed on a large number of B-52G and H aircraft, the AN/ALQ-T4 is just now being modified to reflect these changes. Given the limited availability of training time on the ALQ-155 system in the B-52, the EWO station could have been a boon for procedural training. Unfortunately, the CTA program was cancelled, and the concept test was terminated before the EWO station could be installed and tested on the T-39B.

Since an operational test of the EWO station was not possible, an alternative method of evaluation was designed. This involved having instructor EWOs from 1CEVG operate the system and make judgments concerning its fidelity and training utility. Such judgments would provide at least partial answers to the two questions mentioned previously.

METHOD

Two 1CEVG EWOs travelled to ASD/ENETV at Wright-Patterson AFB to test the EWO station. This evaluation involved rating the EWO station in terms of two areas: (a) fidelity of particular systems with regard to B-52 systems and (b) the training capability of particular systems. The ratings were done on a seven point scale. Table D-1 presents the verbal descriptions associated with each of the ratings.

The ratings were done during several missions run on the EWO station. Each piece of equipment to be evaluated was tested in various modes of operation. Each system was rated in a number of areas, such as in the appearance or

operation of controls. Figure D-1 presents the data recording form used. Each of the systems that were evaluated is listed, subdivided into particular areas. Each evaluator rated each item.

RESULTS

Since the inter-rater reliabilities for both fidelity and training capability were extremely high (r = .89 and r = .93, respectively), the ratings from the two evaluators were averaged to arrive at a mean rating for each item. The mean ratings are represented in Figure D-1 by the underlinings on each scale. For example, 6 represents a mean rating of 6, while 6__5 represents a mean rating of 5.5. In general, the ratings were fairly high, indicating that the equipment closely approximated the B-52 in appearance and operation and could have provided significant training. Where the ratings were low, comments clearly indicated the problem. The following paragraphs summarize the specific comments concerning each system.

ALR-20. The primary problem with threat and jammer appearance was that they were too perfect. The representations were very clear and symmetrical, unlike the aircraft. This simplified operations on them. Also discontinuities in the traces prevented the audio detent function from working properly all across the trace, and there was no audio from the RF test signals.

ALR-46. The symbols were smaller than those on the B-52 ALR-46, making them harder to discriminate. Rather unrealistically, they all moved in a single direction and at the same speed. The audio characteristics of the threats were not completely realistic. The rotation function for the diamond worked somewhat differently from the B-52.

ALQ-117. The self-test function did not work exactly like the one in the B-52. The displays themselves were not quite realistic.

ALQ-155. No BIT test was available. There was also some jumpiness in the frequency control. There were clear discontinuities in bandwidth adjustments as well.

ALE-24. There was a problem with a delay in the first burst when the system was activated. There also were no fault lights.

ALE-20. One notable problem was that the system did not reset to the programmed setting after being operated. Also, because of differences in the types of controls, it was not possible to operate the system in a realistic fashion.

MEP. No problems were noted.

DISCUSSION

The general evaluation of the EWO station was positive. Both in terms of fidelity and training capability, the instructor EWOs felt that the system was fairly successful. Many of the small differences in appearance or operation were unimportant. Most of the problems would be correctable, depending on the size/weight constraints of the aircraft. The EWOs felt that the system would have been particularly useful as a procedures trainer for the ALQ-155 system.

How do these results relate to the two questions mentioned earlier? First, the concept of a light weight microprocessor-based EWO training system was successfully validated. The system would have been able to provide some training even though it fit within the weight and size constraints of the T-39B. In terms of the equipment needed for a CTA, both instructor EWOs felt that more of the systems should be included in the simulation, such as the ALQ-122, to provide more complete training. Also, a wider variety and greater number of threat signals should be available. On the fidelity issue, the only major problem concerned the appearance of signals on the ALR-20A. Their fidelity may be limited by the means by which they are produced. However, they could probably be degraded somewhat so as to be

more realistic. A minor problem arose concerning a control on the ALE-20. In general, the EWOs stated that the controls should replicate the B-52 as exactly as possible, especially where this affects system operations.

In summary, the EWO station met the requirements of the concept test. It provided proof that a microprocessor system could be built which met the specifications for size and weight and still provided the opportunity for training. Since the issue in this test was primarily one of demonstrating technology, the problem of fidelity was not critical. Any future systems actually employed in training would require realistic threat and jammer displays. Other changes recommended for any future CTA EWO station would be that additional equipment be simulated and minor changes in controls be made to provide more realism.

Table D-1. **Definitions for Ratings Used in Evaluating the EWO Station**

Fidelity Rating: Evaluation	Fidelity Rating: Rating	Training Capability Rating: Evaluation	Training Capability Rating: Rating
The features and characteristics are identical to the aircraft.	7	Training can be accomplished which cannot be accomplished in the aircraft or the flight environment.	7
The feature is almost identical to the aircraft. Has *no effect* on EWO tasks.	6	Training capability is comparable to that *of the aircraft*. Skills *can be developed* and maintained by a highly qualified/skilled EWO.	6
Minor deviations are apparent. May have a *slight effect on complex* EWO tasks.	5	Training capability is slightly less than *that of the aircraft. Operational training* in addition to complete transition and procedures training can be accomplished.	5
Significant differences exist. May affect complex tasks but do not affect normal tasks.	4	Training capability is less than that of the aircraft. Complete transition and procedures training can be accomplished.	4
Differences affecting performance and operation exist. Some characteristics desired for normal task performance are missing, degraded, or unrealistic.	3	Training capability is much less than that of the aircraft. Only procedures and partial transition training can be accomplished.	3
Differences *affecting performance and* operation are prominent.	2	Training capability is limited. Suitable for partial procedures training only.	2
Differences are severe. EWO task *accomplishment is precluded.*	1	Training capability is of no or very limited value. *Negative training could result.*	1
Not evaluated.	X	Not evaluated.	X

System	Fidelity	Training Capability
ALR-20		
a. Threat appearance	7 6 5 $\underline{4}$ 3 2 1 X	7 6 5 $\underline{4}$ 3 2 1 X
b. Jammer appearance	7 6 5 $\underline{4}$ 3 2 1 X	7 6 5 $\underline{4}$ 3 2 1 X
c. Expansion trace operation	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
d. Sweep width control	7 6 _ 5 4 3 2 1 X	7 6 _ 5 4 3 2 1 X
e. Audio detent	7 6 5 4 3 2 1 X	7 6 5 4 $\underline{3}$ 2 1 X
f. RF gain	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
g. Controls		
1. Appearance	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Operation	7 6 _ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
ALR-46		
a. Threat indications	7 6 5 $\underline{4}$ 3 2 1 X	7 6 $\underline{5}$ 4 3 2 1 X
b. Audio operations		
1. Threat characteristics	7 6 5 $\underline{4}$ 3 2 1 X	7 6 5 _ 4 3 2 1 X
2. Diamond audio	7 _ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
c. Handoff function		
1. Unlatched position	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Rotation of diamond	7 6 5 4 _ 3 2 1 X	7 6 5 $\underline{4}$ 3 2 1 X
d. Altitude function	7 6 5 4 3 2 1 $\underline{X}$	7 6 5 4 3 2 1 $\underline{X}$
e. File changes	7 _ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
f. Priority function	$\underline{7}$ 6 5 4 3 2 1 X	7 6 5 4 3 2 1 $\underline{X}$
g. Unknown function	7 6 $\underline{5}$ 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
h. Search function	7 $\underline{6}$ 5 4 3 2 1 X	7 6 _ 5 4 3 2 1 X
i. Controls		
1. Appearance	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Operation	7 6 $\underline{5}$ 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
ALQ–117		
a. Threat and jammer indications	7 $\underline{6}$ 5 4 3 2 1 X	7 6 5 _ 4 3 2 1 X
b. Controls		
1. Appearance	7 6 $\underline{5}$ 4 3 2 1 X	7 6 _ 5 4 3 2 1 X
2. Operation	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
c. Displays	7 6 $\underline{5}$ 4 3 2 1 X	7 6 $\underline{5}$ 4 3 2 1 X
d. Correlation with ALR-46	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X

Figure D-1. **EWO station evaluation data form.**

System	Fidelity	Training Capability
ALQ-155		
a. Mode selector	7 6 $\underline{5}$ 4 3 2 1 X	7 6 5 _ 4 3 2 1 X
b. Frequency control	7 6 $\underline{5}$ 4 3 2 1 X	7 6 5 $\underline{4}$ 3 2 1 X
c. BW control	7 6 5 4 $\underline{3}$ 2 1 X	7 6 5 $\underline{4}$ 3 2 1 X
d. Indicator light	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
e. Function switches	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
f. Manual mode		
1. Operation	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Error indications	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
g. Semi-automatic mode		
1. Operation	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Error indications	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
h. Automatic mode		
1. Operation	7 6 $\underline{5}$ 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Error indications	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
i. Stack indications	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
j. Modulation selector	7 6 _ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
ALE-24		
a. SPD operations	7 6 5 4 3 $\underline{2}$ 1 X	7 6 5 4 3 $\underline{2}$ 1 X
b. DOC operations	$\underline{7}$ 6 5 4 3 2 1 X	$\underline{7}$ 6 5 4 3 2 1 X
c. Indicators	7 6 5 4 3 $\underline{2}$ 1 X	7 6 5 4 $\underline{3}$ 2 1 X
d. Controls		
1. Appearance	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Operation	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
ALE-20		
a. Dispensing operations	7 6 5 4 3 $\underline{2}$ 1 X	7 6 5 4 3 2 _ 1 X
b. Programming operations	7 6 5 4 _ 3 2 1 X	7 6 5 4 $\underline{3}$ 2 1 X
c. Indicators	7 $\underline{6}$ 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
d. Controls		
1. Appearance	7 6 $\underline{5}$ 4 3 2 1 X	7 6 _ 5 4 3 2 1 X
2. Operation	7 6 5 4 3 $\underline{2}$ 1 X	7 6 5 4 3 2 $\underline{1}$ X
MEP		
a. Chaff operation	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
b. Flare operation	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
c. Controls		
1. Appearance	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X
2. Operation	$\underline{7}$ 6 5 4 3 2 1 X	7 $\underline{6}$ 5 4 3 2 1 X

Figure D-1. **EWO station evaluation data form** (*Concluded*)